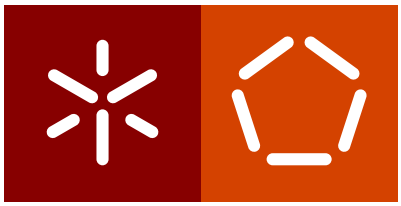

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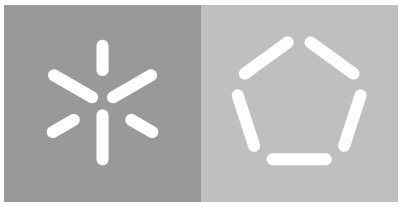

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A Smart City Guideline Based on the Main Standard Activities

Master dissertation
Master Degree in Engenharia Electrónica Industrial e Computadores

Dissertation supervised by
Professor Doutor Henrique Santos
Professor Doutor Sérgio Lopes

December 2018

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ABSTRACT

Cities are growing at an unprecedented rate and is expected that by the year 2050, 70% of the world's population will live in cities. This rapid urban growth led to increased traffic congestion, pollution, energy consumption and social inequalities in some cities. To ensure the survival of future generations, cities have to become "smarter".

A possible solution to the problems previously stated is to adapt the Internet of Things (IoT) to cities, where thousands of devices are permanently monitoring critical city's parameters. Adapting this concept to implement sustainable programs, with the main goal of increasing the quality of life in cities, led to the idea of "Smart Cities". In a Smart City, new information and communication technologies are used to ensure a sustainable urban development for all citizens.

To ensure that Smart City activities are implemented in the right way, a correct use of the main standards in force is crucial. Standardization can help to maximize interoperability between different stakeholders while ensuring compatibility with previous projects.

This dissertation aims at presenting a Smart City Guideline, through an in-depth characterization and study of the main Smart City standards. From the study of the main standards, it is possible to draw metrics that can result in a guideline of good practices for implementing initiatives in this new challenging environment. This guideline can and should be used by governments and organizations that want to implement sustainable urban programs, regardless of the area and number of inhabitants on their cities.

RESUMO

As cidades estão a crescer a um ritmo nunca antes visto, estimando-se que cerca de 70% da população mundial habite em cidades no ano 2050. Este rápido crescimento urbano levou ao aumento do trânsito, da poluição, do consumo energético e das desigualdades sociais em algumas cidades. Para garantir a sobrevivência das populações futuras, existe a necessidade de tornar as cidades mais "inteligentes".

Uma possível solução para estes problemas passa pela utilização da Internet das Coisas (IoT) adaptada a cidades, onde milhares de dispositivos são instalados e a monitorização de várias variáveis, em tempo real, passa a ser possível. Utilizando este conceito para tomar medidas sustentáveis, com o principal objetivo de melhorar a qualidade de vida nas cidades, levou à criação da ideia de "Cidades Inteligentes". Numa Cidade Inteligente são utilizadas as novas tecnologias de informação e comunicação para assegurar um desenvolvimento urbano sustentável para todos os cidadãos.

Para que as iniciativas e projetos, relativos a Cidades Inteligentes, sejam implementados com sucesso, é crucial recorrer à normalização. Assim, diferentes *stakeholders* partem para os projetos com uma base, visão e linguagem comum, além de garantir que novas iniciativas implementadas estão de acordo com os trabalhos anteriores.

Esta dissertação tem como principal objetivo a apresentação de um guia de implementação de atividades sustentáveis numa Cidade Inteligente, com base nas principais normas em vigor deste novo e desafiante ambiente. Através de um estudo aprofundado das normas, é possível retirar métricas que resultam num guia de boas práticas para implementações de iniciativas sustentáveis. Este guia, pode e deve ser usado por autarquias e organizações que pretendem implementar medidas de crescimento urbano sustentáveis, independentemente da área e número de habitantes das suas cidades.

CONTENTS

LIST OF FIGURES

ACRONYMS

A

ADSS Advanced Digital Signature Services.

B

BSI British Standards Institution.

C

CEN European Committee for Standardization.

CENELEC European Committee for Electrotechnical Standardization.

E

ETSI European Telecommunications Standards Institute.

G

GPS Global Positioning System.

I

.

IEC International Electrotechnical Commission.

IEEE Institute of Electrical and Electronics Engineers.

IOT Internet of Things.

IP Internet Protocol.

ISO International Organization for Standardization.

ITU International Telecommunication Union.

ITU-T ITU Telecommunication Standardization Sector.

J

JTC Joint Technical Committee.

P

PAS Publicly Available Specification.

PKI Public Key Infrastructure.

S

SCCM Smart City Concept Model.

SCF Smart City Framework.

SCG Smart City Guideline.

T

TC Technical Committee.

TR Technical Report.

1

INTRODUCTION

This chapter contextualizes this work, defines the main objectives and presents the dissertation outline.

1.1 CONTEXT

A great number of physical objects are being connected to the Internet at an unprecedented rate. The European Commission has predicted that by 2020 there will be more than 50 billion devices connected to the Internet, although the number of connected devices has already surpassed the number of people in 2008, as can be seen in Figure 1 [1]. This phenomenon is called *Internet of Things (IoT)*. A thing, in the IoT, can be a computer, a traffic light, a smart phone, a car or any other object that can be assigned an *Internet Protocol (IP)* address and provided with the ability to transfer data over a network. Also, IoT devices are capable of co-operating with one another by sharing information. With these continuous interactions between objects, several concepts and applications have emerged, such as smart cities, smart homes or smart grids [2].

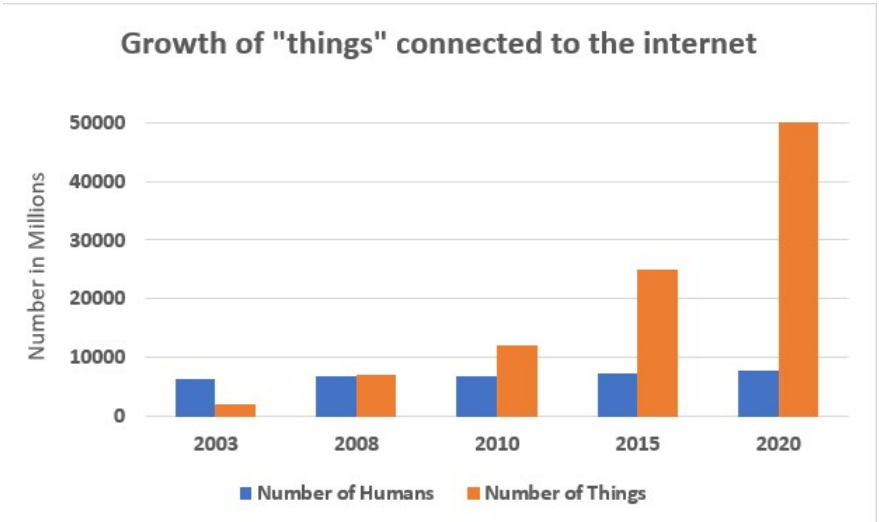

Figure 1: Comparison between the number of humans and things connected to internet [1]

Along with many devices, comes a huge amount of data that needs to be collected and processed. In IoT, all devices are connected to provide services at any time and place but most of them are not equipped with efficient security mechanisms. These devices are vulnerable to various privacy and security issues, so is necessary to implement some level of security when exchanging information [3][4]. Also, it is important to ensure that there is a solid infrastructure that guarantees the processing and storage of the generated data. It means not only to ensure a high performance data transmission rate but also proper data preparation [5].

1.2 MOTIVATION

According to the United Nations, the world population is expected to reach nearly 10 billion people by 2050 and 70% of this population will live in cities [6][7]. With this migration to urban areas, cities must deliver the resources and services needed to ensure their populations survival. Transportation, energy, security and pollution are some of the pressure points that are being affected by rising urbanization [8][9]. So cities need to become "smarter", by increasing the quality of the services offered to the citizens, while reducing the operational costs of the public administrations. This can be possible by deploying thousands or even millions of small devices in the urban area, which are permanently gathering and exchanging information, creating an urban IoT, also called Smart City [10][11]. This information can be used to optimize the public services such as parking, lighting or traffic. Furthermore, the collected data can be used to give a real time status of the city to their citizens.

To keep pace with the rapid growth of cities, governments and communities need to implement new strategies and processes to ensure that Smart City programs and initiatives are implemented in the right way. So, the standardization will play a key role in the implementation of Smart City projects, since standards provide people and organizations with a basis for mutual understanding and are used as tools to facilitate communication, commerce and manufacturing, while ensuring that new projects match the specifications previously stipulated, since standards are means of assuring customers that products and services have the appropriate degree of quality, safety and respect for the environment.

Adapting a city that fully integrates the IoT concept is complex and expensive, justifying the development of a simulator able to generate heaps of information, relate it, ensure security and finally, predict limitations. To achieve this goal, the creation of a laboratory is crucial, where different scenarios can be tested and many technologies can be evaluated, in a controlled environment.

So, the development of this dissertation takes place in a security laboratory focused on the field of smart cities. This laboratory is called LabSecureIoT and emerges as a result of the partnership between the Department of Information Systems, University of Minho and

the company DigitalSign SA (EU / eIDAS Qualified Trusted Service Provider). Such partnership focuses on fostering educational and research projects regarding electronic Trust Services. With this aim in mind, DigitalSign provides free access to students and researchers to the *Advanced Digital Signature Services (ADSS)* platform, allowing the development of prototypes for electronic trust services, by using digital certification and strong authentication. As the name of the laboratory says (LabSecureIoT), information security will be the core requirement of any prototype or model developed. So, the confidentiality (only those who have permissions should access the information) and integrity (data must not be changed in transit and cannot be altered without proper authentication) of information must be kept [12]. To ensure this, digital certification and *Public Key Infrastructure (PKI)* will be used in the developed projects.

1.3 OBJECTIVES

The main objective of this dissertation is the proposal of a Smart City guideline. This guideline should be the result of an in depth study of the main standards in force, in a Smart City environment. To achieve this goal, it is necessary to first understand the importance of standardization and which are the main standards in force in a Smart City context.

The in depth study of the standards should result in metrics, or a list of good practices, that should be kept to guarantee the success of Smart City programs. This list of good practices should also come from the study of the main successful Smart City initiatives already implemented. In addition, a study of the impact of the standards in the main Smart City stakeholders should be conducted, in order to evaluate if the conclusions achieved from the standards study match the priorities and intentions of these stakeholders groups. The cross-information retrieved from the standards and successful initiates, and their impact on society should result in a more completed guideline.

So at the end of this dissertation, it is supposed to exist an answer to the following question: *Which are the requirements or good practices, suggested by the standards and stakeholders, that increases the success of a Smart City project and which are the main significant examples of cities that implemented these good practices?* To achieve this, it is first necessary to know how to define a Smart City and how to categorize the existing types of standards, identifying the main Smart City stakeholders and their importance for the success of Smart City projects.

1.4 THESIS OUTLINE

This dissertation is composed by five chapters. In Chapter 1 the work is contextualized, the main issues to address are enunciated and general objectives are described. The second

chapter describes the State of the Art, identifying the main Smart City definitions and standards, as well as the examples of success in implementing Smart City initiatives. In Chapter 3 is presented a study evaluating the implementations effects of the standards on society, where a survey, carried out on the population and the respective conclusions, but also an interview, made to an Advisor to the City Councillor of Braga, are presented. The Chapter 4 represents the Smart City guideline and, in Chapter 5, are presented the main conclusions and prospects of future work.

2

STATE OF THE ART

In the first part of this chapter are presented several definitions of Smart City and the areas that characterize them. The second part provides a literature review on the Smart City standardization while the third subsection presents a set of Smart City successful projects and initiatives.

2.1 CITIES AND SMART CITIES

A city is a large human settlement which tries to aggregate all populations needs in one place. By living in society, humans have access to healthcare and security, while exchanging goods and knowledge, in a faster way. Nowadays, cities are the main engines of economic growth, concentrating most of the world's economic activity [13].

By 2050, 70% of the world's population will live in cities, which represents nearly 7 billion people. This population growth will also increase the number of technical, social, economical and environmental problems [14]. For example, the fast growth of several cities has generated traffic congestion, pollution and social inequality. Thus, with this unprecedented urban growth, leaders must plan new management strategies to make cities attractive to people, workers, tourists and business companies, but also provide communities the ability to overcome problems rather than resorting in government resources [15].

With this issues in mind, technology-based solutions have been developed to assure the sustainable growth of cities, creating a urban IoT that use the new *information and communication technologies (ICT)*, that can be part of a Smart City.

2.1.1 *Smart City Definition*

The definitions of what a Smart City really is are various, since the term is still a vague concept. Many questions can be asked about this environment, such as: *Which are the requirements that characterize a Smart City?* or *How do citizens know that they live in a Smart City?* The answers to these questions aren't also clear or unique. One possible reason is

that, different stakeholders have their own understanding of what a Smart City is, from divergent perspectives [16].

In order to understand the Smart City concept in its entirety, it is first necessary to define the label "Smart". In a document published by the *British Standards Institution (BSI)*, *Smart cities – Vocabulary*, the label "smart" is defined as:

> **Smart:** *"The application of autonomous or semi-autonomous technology systems to achieve greater utilization of resources, limiting or reducing per capita resource consumption to maintain or improve quality of life"*[17] (p.12).

So, the "smartness" of a city can be as simple as a single function provided to a certain group of citizens or as complicated as an entire administration process which represents the restructuring efforts of government procedure.

Also, each city is unique, having its own history, traditions, area and population. Therefore, it is difficult to formalize a Smart City definition. Many international groups and organizations are working to deliver a unique solution to this problem, proposing their own definitions, such as:

- The BSI defines a Smart City as a *"term denoting the effective integration of physical, digital and human systems in the built environment to deliver a sustainable, prosperous and inclusive future for its citizens."* This definition is deliberately presented as a "working definition" rather than intended as a "definitive definition", which all cities should follow [17].
- The *Institute of Electrical and Electronics Engineers (IEEE)* use the Smart City definition from *International Telecommunication Union (ITU)* that defines a smart sustainable city *"as an innovative city that uses ICT to improve quality of life and make urban operation and services more effective, while ensuring that it meets the needs of present and future generations with respect to economic, social, environmental and cultural aspects". [18]*
- The *International Organization for Standardization (ISO)* Smart Cities Strategic Advisory Group defines a Smart City as one that *"dramatically increases the pace at which it improves its social economic and environmental outcomes, responding to challenges such as climate change, rapid population growth and economic instability, by fundamentally improving how it engages society, how it applies collaborative leadership methods, how it works across disciplines and city systems, and how it uses data information and modern technologies, in order to provide better services and quality of life to those in and involved with the city (residents, businesses, visitors), now and for the foreseeable future, without unfair disadvantage of others or degradation of the natural environment [18]."*

It can be concluded that a Smart City is a multidisciplinary concept that embodies not only the city's information technology infrastructure but also its capacity to manage new

information and resources. The ”smart” label is related to the fact that the use of technology makes the city sense, monitor, control and communicate most of its services [15]. While the exact definition varies, the main mission of a Smart City is to optimize city functions and drive economic growth while improving quality of life for its citizens, using smart technology and data analysis[19].

A Smart City should then be seen as a system of systems of systems and not as a group of smart applications working on their own. The term ”Smart City” doesn't have a unique definition but it's something that is in constant evolution. Therefore, a major effort is required to develop a core set of principles to guide the future direction of urban sustainability [16].

2.1.2 *Smart City Areas*

While the proposed definitions of Smart City are debatable, it is easier to identify the main areas where each city can act to transform itself into a Smart City.

In a report that ranked medium-sized cities in accordance to their ”smart” performance, published by the Universities of Vienna and Delft, in collaboration with the Department of Geography of the University of Ljubljana in the year 2007, are identified six dimensions where a city should have visionary performances, in order to be considered a Smart City. Each dimension, or ”Smart City area”, is therefore defined by a number of factors and each factor is described by a number of indicators. These dimensions are:

1. **Smart Economy**: that includes factors all around economic competitiveness;
2. **Smart People**: that includes factors like citizens qualification or education but also participation in public activities;
3. **Smart Governance**: that comprises aspects of political participation and services for citizens;
4. **Smart Mobility**: that includes important aspects like local and international accessibility but also the sustainability of the city's transport system;
5. **Smart Environment**: that includes factors around the natural conditions and pollution; and
6. **Smart Living**: that comprises various aspects around of quality of life as culture and tourism.

All cities are unique, however they rarely face unique challenges [20]. By using a group of similar indicators, it is possible to compare cities from all over the world and rank them according to their ”smartness” level. One of the great benefits of using this topology, is

the fact that it can by applied to cities of all sizes, although in this particular study, it was applied to cities with no more than 100,000 inhabitants. Figure 2 illustrates the 6 dimensions or Smart City areas and their assigned factors [21].

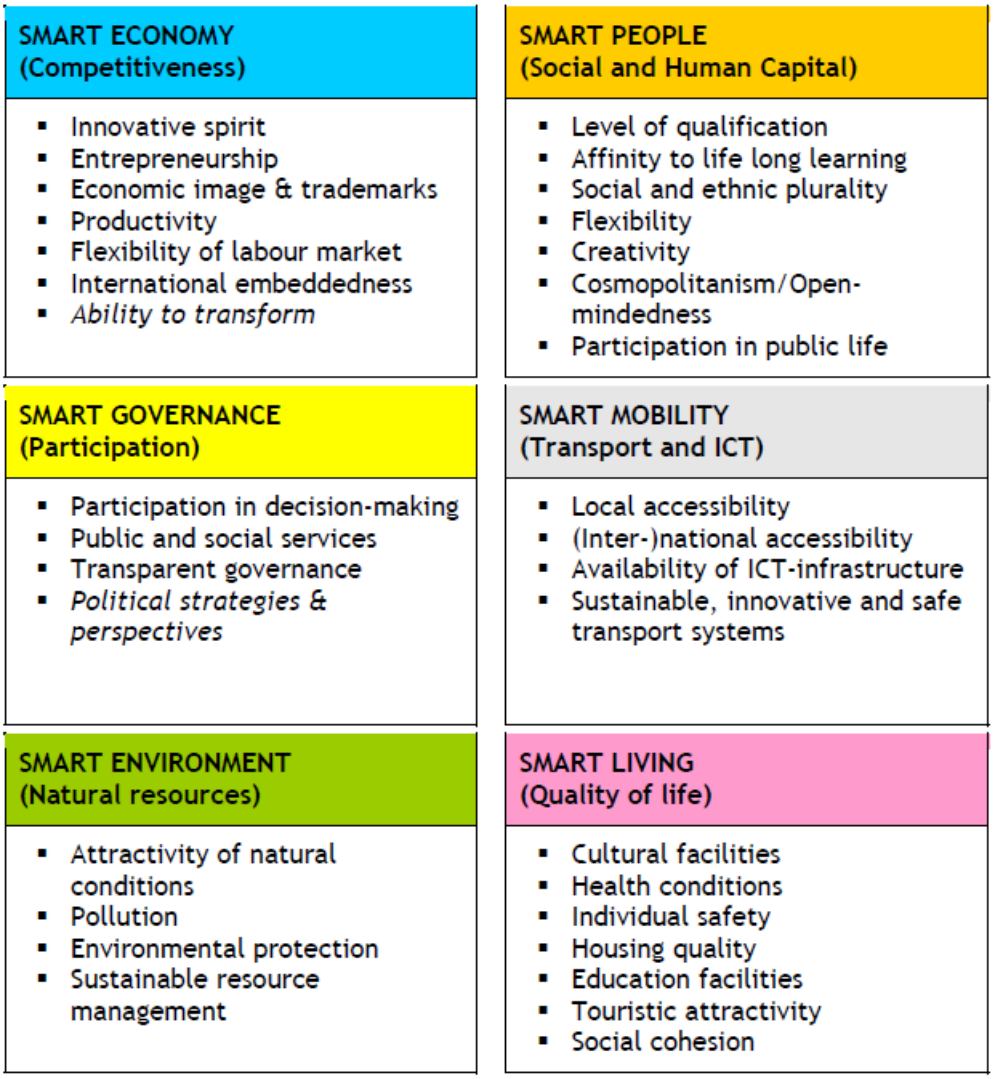

Figure 2: Dimensions and factors of a Smart City (Ranking of European Medium Sized Cities)

The six dimensions or areas identified in this report, served as inspiration to many Smart City models. Brussels, with the project Brussels Smart City [22] and Newcastle, with the Newcastle Smart City Program [23] are some examples of cities that use these dimensions to implement their Smart City projects.

2.2 SMART CITY STANDARDIZATION

As the definition of a Smart City is not unique, standards will play a key role in the implementation of Smart City projects, since standards provide people and organizations with a basis for mutual understanding and are used as tools to facilitate communication, measurement, commerce and manufacturing. In essence, a standard is an agreed way of doing something [24]. Specifically in a Smart City, standards can provide the following benefits [18]:

- Integration between separated systems by defining how to achieve interoperability;
- Integration between the physical and digital worlds, since smart cities need reliable and resilient physical and technology infrastructures, working together;
- Standards can help to provide a shared language and tested methodologies to minimize misunderstandings between different stakeholders;
- Help to prevent vendor lock-in, by breaking down products into smaller parts, finding the best provider of each part;
- Enable scalability.

Since the number of published standards, dedicated to smart cities is too large, it is necessary to first categorize each standard.

2.3 LEVELS OF SMART CITY STANDARDS

The BSI published a report (PD 8100 Smart Cities Overview) that provides guidance for city leadership on the applicability of Smart City approaches to their city [25]. City leadership includes everyone in a strategic position within a city whose decisions have a significant impact on the way the city functions and develops, whether they are from the public, private or community sectors. This report also covers the role of standards, based on good practice from successful Smart City initiatives, where a useful framework, that categorizes standards by levels, is presented (Figure 3).

As can be seen in Figure 3, the publish standards are categorized in 3 separated levels:

- **Level 1 - Strategic:** these are Smart City standards that *"provide guidance to city leadership on the process of developing a clear and effective overall smart city strategy, identifying priorities, and developing a practical implementation roadmap and an effective approach to monitoring and evaluating progress" [25](p.21)*;

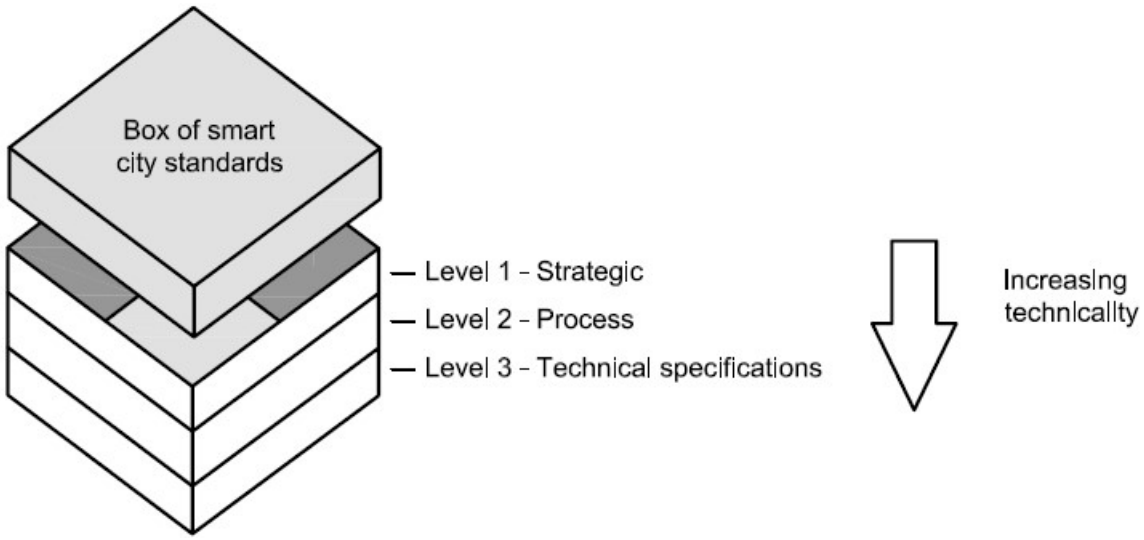

Figure 3: Levels of Smart City standards (Copyright PD 8100 BSI 2015)

- **Level 2 - Process:** these standards *"cover good practice in procuring and managing cross-organizational and cross-sectorial smart city projects, including guidance on putting together appropriate financing packages" [25](p.21)*;
- **Level 3 - Technical:** these standards *"cover the practical requirements for smart city products and services to ensure that they achieve the results needed" [25](p.21).*

All the three levels of Smart City standards have their own importance in the implementation of Smart City initiatives but, the first two levels are directed to people in leadership and management posts, meaning that they will represent the core standards for this dissertation. As the BSI states:

> *"Strategic-level standards are of most relevance to city leadership and process-level standards to people in management posts. However, even technical specifications are relevant to people in management posts as they need to know which standards they need to refer to when procuring technical products and services [25] (p.21)."*

2.4 Position and group standards activities

With the presented framework, is possible to fit each standard into one of the levels. In the same published document (PD 8100 Smart Cities Overview), the BSI highlighted the main international body activities which they are collaborating with and placed them in the framework (Figure 4). The main international body activities include ISO, the *European Committee for Standardization (CEN)*, the *European Committee for Electrotechnical Standardization (CENELEC)*, the *European Telecommunications Standards Institute (ETSI)*, the *ITU Telecom-*

munication Standardization Sector (ITU-T) and the *International Electrotechnical Commission (IEC)*. It is important to note that a single body activity may publish standards in different levels.

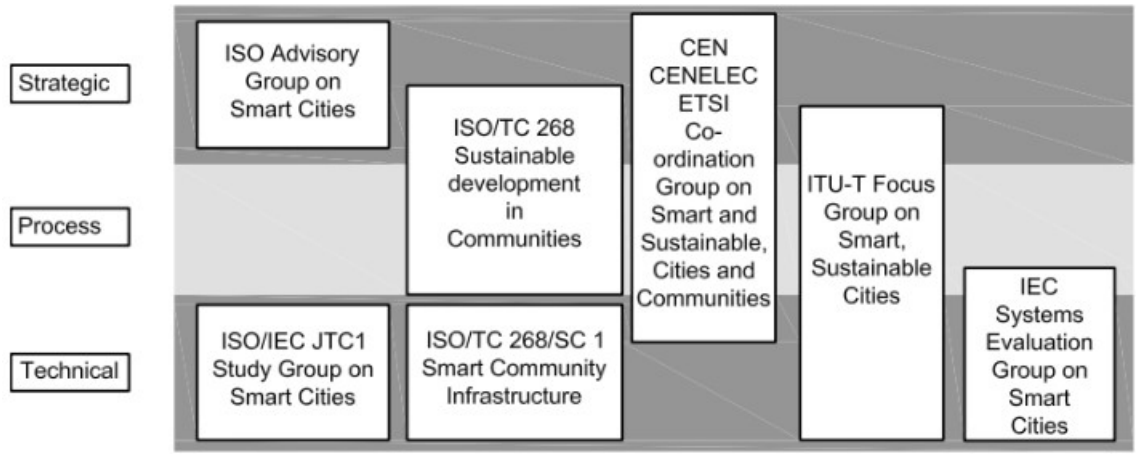

Figure 4: International Smart City Standardization Activities (Copyright PD 8100 BSI 2015)

As can be seen in Figure 4, ISO created a *Technical Committee (TC)* just to publish Smart City standards which is also working in partnership with IEC, within *Joint Technical Committee (JTC)* 1.

2.5 STRATEGIC STANDARDS

The main objective of the strategic standards is to help developing a clear and effective Smart City strategy, providing guidance to city leaders. Some of the strategic standards are the ISO 37120 and the ISO 37101.

2.5.1 *Strategic Standard: ISO 37120*

ISO 37120 Sustainable development [1] of communities — Indicators for city services and quality of life. The first edition of this standard was published in 2014 by the ISO's Technical Committee 268 and provides methodologies and definitions for a set of standardized indicators that can match the performance of cities in terms of sustainable urban development and quality of life.

City indicators can be used as critical tools for city managers to help ensure that policies are put into practice that promote liveable, inclusive, sustainable, resilient, economically attractive and prosperous cities globally. The requirements contained in this standard are

1 ISO define **sustainable development** as *"development that meets the environmental, social and economic needs of the present without compromising the ability of future generations to meet their own needs."*

applicable to any city or local government that want to measure its performance in a comparable and verifiable manner [26]

In this document, are identified 100 indicators grouped in 17 sections, which are: Economy, Education, Energy, Environment, Finance, Fire and emergency response, Governance, Health, Recreation, Safety, Shelter, Solid waste, Telecommunication and innovation, Transportation, Urban planning, Wastewater and Water and sanitation. Each indicator can be a core one, which cities shall track and report, or a support one, that cities should track and report. Also, each indicator has specified requirements that help governments on how to report the collected data.

As an example, the Environment section has a total of 8 indicators, 3 cores and 5 supports. One of the core indicators is the Fine particulate matter (PM2.5) concentration. Cities and organizations implementing this standard shall report on this indicator in accordance with the following requirements: (1) Fine particulate matter (PM2.5) concentration shall be calculated as the total mass of collected particles that are 2.5 microns or less in diameter divided by the volume of air sampled. The result shall be expressed as the concentration of PM2.5 in micrograms per standard cubic meter ($\mu g/m^3$); (2) The method for measurement shall involve the use of an air sampler which draws ambient air at a constant flow rate into a specially shaped inlet where the suspended particulate matter is inertially separated into one or more size fractions within the PM2.5 size range. The 24-hour (daily) measurements of PM2.5 concentrations are forwarded to a database where yearly summaries for each monitoring stations are computed.

One of the support indicators, in the Environmental section, is the Noise pollution. This indicator should be reported in accordance to the following requirements: (1) Noise pollution shall be calculated by mapping the noise level Lden (day-evening-night) likely to cause annoyance, identifying the areas of the city where Lden is greater than 55 dB and estimating the population of those areas as a percentage of the total city population. The result shall be expressed as the percentage of the population affected by noise pollution. Users of this standard should note that noise pollution can also be recorded as Ln (night) and when exceeding 50 dB is likely to cause sleep deprivation; (2) Average concentrations are measured by monitoring equipment and reported to the city's monitoring authority.

Therefore ISO 37120 can help governments by providing the standardized indicators that enable cities to assess their performance and measure progress over time and also to draw comparative lessons from other cities. Standardized indicators also help to guide policy, planning and management across multiple sectors and stakeholders.

ISO's Technical Committee 268 is preparing a new version of this standard, that will be published in 2018 [27].

2.5.2 *Strategic Standard: ISO 37101*

ISO 37101 Sustainable development in communities - Management system for sustainable development was published in 2016 by the ISO's Technical Committee 268 and has been developed to help city leaders create a vision for the future of their cities and implement steps to achieve sustainable development goals.

This international standard sets out requirements and guidance to help communities achieve a framework that will allow them to become more sustainable, but it does not set expected levels of performance. While the challenge of sustainable development is global, the strategies for achieving it at community level are local and can differ in context and content from country to country or region to region. Community strategies need to reflect the context, preconditions, priorities and needs, particularly in the social environment, as examples, social equity, cultural identity and traditions, human health, safety and social infrastructure [28].

This International Standard is based on the Plan-Do-Check-Act (PDCA) cycle, a four-step management method used by organizations for the control and continual improvement of processes, products and services that can be described as: **Plan**: establish objectives and processes necessary to deliver results in accordance with community purposes; **Do**: implement processes and achieve objectives; **Check**: monitor and measure processes against community policy, objectives and commitments, and report the results; **Act**: take necessary actions to improve performance.

ISO 37101 will also bring additional benefits to communities [29]. For example:

- Following this standard may require the creation of a specific structure within a community that is used to drive the sustainable development process. Defining this structure, where the future of the community can be discussed openly between all stakeholders may create new ideas and visions;
- ISO 37101 puts a strong emphasis on involving all interested parties in discussions to define and implement a sustainable development strategy. Citizens of a community are one of the most important stakeholder groups, so any future development of the community should reflect their needs;
- This standard underlines the importance of deciding collectively on objectives, a strategy and a timeline in which to get there; this gives greater visibility to different stakeholders as to the sustainable development approach adopted by the community.

The main goal of implementing ISO 37101 is to create a more sustainable future for communities, enhancing the importance of collaboration between may different stakeholders. This means an improved local environment, a happier and healthier place for citizens, and a community that can better anticipate and adapt to natural disasters and economic shocks.

2.6 PROCESS STANDARDS

While strategic standards aim to provide guidance to city leaders, process standards are focused on procuring and managing smart city projects and, many times, also address strategic aspects. These standards offer the best practices to implement Smart City projects and usually present associated guidelines.

Since the main objective of this dissertation is the proposal of a Smart City guideline, that takes into consideration the best practices imposed by the Smart City standards and some successful initiatives, process standards represent the most important level of standards to be studied in depth. Considering this, some of the process standards are the PAS 181, PAS 182 and PAS 184 [2]. In the scope of this dissertation, a PAS is referred as a standard.

2.6.1 *Process Standard: PAS 181*

The PAS 181 Smart city framework – Guide to establishing strategies for smart cities and communities was published by BSI in 2014 and will be published as an international standard (ISO 37106) in 2018 [31]. In this document is presented a *Smart City Framework (SCF)* that refines current good practices (identified by a broad range of public, private and voluntary sector practitioners engaged in facilitating smart cities) into a set of consistent and repeatable patterns. City leaders can use these patterns to help them develop and deliver their own Smart City strategies.

PAS 181 presents the traditional operation model (Figure 5) where cities have come from. This model has been based around functionally-oriented service providers that operate as unconnected vertical silos, which are often not built around user needs. Citizens have to engage with each silo, in a separated way, while making connections for themselves. Also, data and information is often labelled and locked within the services in each silo, limiting the potential for collaboration and innovation between different parties across the city. As the BSI states: *"smart cities need to develop new operating models that drive innovation and collaboration across these vertical silos"*.

The Smart City concept, enhanced in PAS 181, aims to finish with the separation of the different silos, trying to give citizens a connected service that meets their needs and crosses all services. BSI proposes a set of changes to this traditional way of operating, which smart cities are trying to implement, resulting in the SCF. This changes, to a smarter a city, include [32]:

2 When standards don't cover a certain area, *Publicly Available Specification (PAS)* can be published. A PAS is basically a publication responding to an urgent market need. The objective of a PAS is to speed up standardization in areas of rapidly evolving technology [30]. The development of a PAS cannot conflict or contradict with existing formal standards and must complement, any legislation in the subject area.

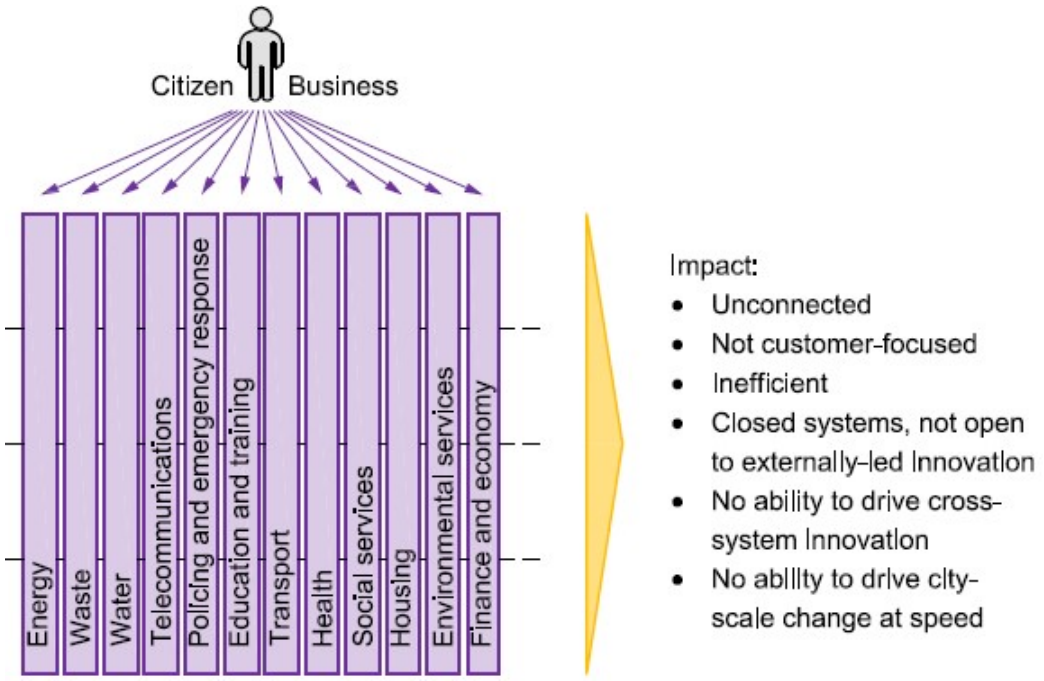

Figure 5: Traditional operating model: where cities have come from (Copyright PAS 181 BSI 2014)

- Investing in smart data, ensuring that digital data, applications and services are available, in real time, in order to enable real time integration and optimization of city resources;
- Managing city data as an asset, with city authorities but also in collaboration with data owners;
- Opening up city data and services both for citizens and local businesses, enabling innovation led by citizens and organizations;
- Deliver sustainable and citizen-centric services, by integrating business and information in an inclusive way; and
- The creation and implementation of systems that allow the public evaluation of the implemented changes.

The SCF can be seen in Figure 6 and provides a detailed set of guidance notes on how to deliver these changes in practice. At the top-level, the SCF is made up of four components:

- **[A] guiding principles:** *a statement of values which city leaders can use to steer business decision making as they seek to implement a Smart City strategy;*
- **[B] key cross-city governance and delivery processes:** *a set of practical guidance notes on how to address city-wide challenges of joining-up across city silos;*

- **[C] benefit realization strategy:** *guidance on how to ensure that the intended benefits of a Smart City strategy are clearly articulated, measured, managed, delivered and evaluated in practice;*
- **[D] critical success factors:** *a checklist of issues which cities should regularly monitor to ensure that they are on track in the successful delivery of their Smart City programmes, and that they are managing the major strategic risks effectively.*

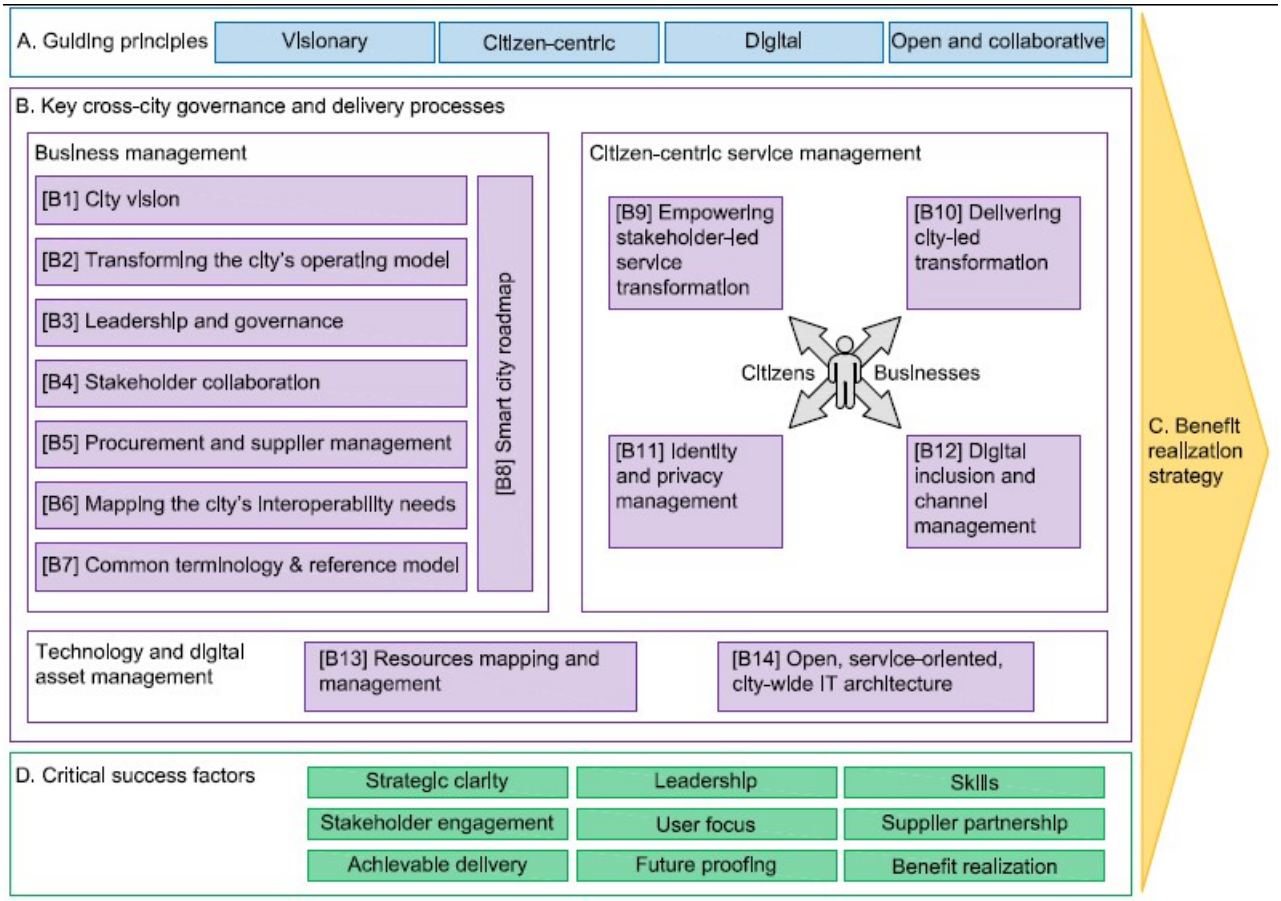

Figure 6: High-level structure of the SCF (Copyright PAS 181 BSI 2014)

For each one of the four components presented in SCF, there are a set of recommendations that may help city leaders to successfully implement Smart City strategies, while abandoning the silo-centric way that cities function.

In the first component of the SCF, **[A] Guiding Principles**, its recommended that Smart City leaders should collaborate with the maximum number of city stakeholders. This collaboration can help develop a set of guiding principles for a Smart City strategy that include: (1) establishing a clear vision for the city; (2) the process of digitalize the city's systems, spaces and services; (3) sharing, in a public way, the way that city works; (4) develop and deliver services, with a citizen-centric approach.

The second component of the SCF, **[B] Key cross-city governance and delivery processes**, delivers guidance on how to put the guiding principles in practice. The main focus of this component is to unify the city silos, mentioned above, in 3 areas: (1) Business management; (2) Citizen-centric service management; and (3) Technology and digital asset management. Each one of these 3 areas have a set of sub-components with unique recommendations.

The Business management area focus on the key aspects of governance that need to be managed at a whole. The sub-components of this area and some of theirs recommendation are:

- **[B1] City Vision recommendations:** Smart City leaders should create a vision of "what good looks like" for their city, now and in the future. This should happen in a way that: (1) the city services are inclusive with all stakeholders; (2) the smart technologies and smart data are used to open and embrace new opportunities; (3) economic, environmental and political visions should be integrated in the city's core strategic objectives; and (4) "what good looks like" should be measurable, allowing comparisons.

- **[B2] transforming the city's operating model recommendations:** Smart City leaders should ensure that the city vision includes the need to develop an integrated city operating model focused around citizens and businesses needs.

- **[B3] Leadership and governance recommendations:** Smart City leaders should ensure that the proposed city vision is sustainable over many years, underwriting the need of different inputs from different stakeholders, erasing the idea of a top-down city program led only by the city authority. Also, a formal programme describing priorities and government activities should be shared in a public way.

- **[B4] Stakeholder collaboration recommendations:** Smart City leaders should promote effective stakeholder collaboration. The participation of all stakeholder groups, that include users, suppliers, politicians or the media, is crucial the success of the Smart City program and leaders should ensure that all these groups have a clear understanding of the initiative and how they will benefit from it. Also, the engagement with other cities might be helpful, by learning lessons and exchange experiences.

- **[B5] Procurement and supplier management recommendations:** Smart City leaders should review polices to ensure that they align with the Smart City contracting principles: focus on business outcomes, build and correlate open data, incentive integration, innovation and collaboration and avoid suppliers lock-in.

- **[B6] Mapping the city's interoperability needs recommendations:** Smart City leaders should promote interoperability and use tools to identify barriers, establish policies and promote connections with other cities or regions.

- **[B7] Common terminology and reference model recommendations:** Smart City leaders should ensure that all stakeholders have a clear understanding of the key concepts of the program to be implemented and how these concepts are related with each other. Also, leaders should seek agreement among stakeholders to establish and use a common terminology.

- **[B8] Smart city roadmap recommendations:** Smart city leaders should plan and deliver the city vision using an effective and phased roadmap, while ensuring that different stakeholders identify and agree on a set of initial deliverables that represent advantages for the city. Also, governments should give priority to low cost a low risk changes that can be delivered quickly, while working with partners and establishing systems that can be improved with customer experiences.

The second area of the [B] component represents the citizen-centric service management and addresses the way in which services are planned and delivered for citizens and businesses. The sub-components of this area and some of theirs recommendation are:

- **[B9] Empowering stakeholder-led service transformation recommendations:** Smart City leaders should empower stakeholders to promote the creation of new services and drive forward the internal culture changes. Generated data should be shared over open platforms.

- **[B10] Delivering city-led service transformation recommendations:** Smart City leaders should deliver public services to citizens and businesses that accessible in one stop and developed around user needs.

- **[B11] Identity and privacy management recommendations:** Smart city leaders should ensure that all personal data is secure and under the ownership and control of the individual citizen, since the Smart City needs Smart Data and the user needs to trust the service in order to share information.

- **[B12] Digital inclusion and channel management recommendations:** Smart city leaders should establish digital inclusion programs that ensure user focus, by including a clear audit of existing channels that can be used to deliver city services, with associated costs, and by including the vision and roadmap of the city program, enhancing the fact that it is centred on the needs of both citizens and businesses.

The third and last area of the [B] component represents the Technology and digital asset management and addresses how changes in these domains can help to accelerate and lower the costs of Smart City initiatives. The sub-components of this area and some of theirs recommendation are:

- **[B13] Resources mapping and management recommendations:** Smart City leaders should pace and map ICTs systems, multiplying the potential sources of city data, ensuring that this data is effectively managed and used in the right way.
- **[B14] Open, service-oriented, city-wide IT architecture recommendations:** Smart City leaders should work with stakeholders to establish an open, service-oriented, IT architecture.

In the third component of the SCF, **[C] benefit realization strategy**, is recommended that Smart City leaders should establish a strategy to ensure a clear path between the vision and the actions to achieve the proposed objectives, enhancing three pillars that should support the strategy: Mapping, Tracking and Delivery.

The forth and last component of the SCF, **[D] Critical success factors:** recommend that Smart City leaders should establish processes to ensure that critical success factors are identified, measured and managed, defending the idea that these factors will help to track the progress of the proposed program.

In conclusion, PAS 181 gives guidance on a good practice framework for decision-makers in smart cities and communities to develop, agree and deliver Smart City strategies that can transition their city's ability to meet future challenges and aspirations, putting the citizen needs and its business at centre.

2.6.2 *Process Standard: PAS 182*

The **PAS 182 Smart city concept model** [3] **– Guide to establishing a model for data interoperability** was published by BSI in 2014.

In a Smart City environment, organizations and citizens have the need to share data. However, data is often labelled using language and terms from the sector that initially collected it. Each sector has its own models and terminologies, for internal use, that forms a barrier to interoperability with other sectors. PAS 182 intents to facilitate discussions between decision-makers from each sector and the specialists who develop and design the systems and services that enable cities to function.

The *Smart City Concept Model (SCCM)* outlined in PAS 182 addresses this lack of interoperability by defining a framework of concepts and relationships that can be used to describe data from any sector. Mapping terms from many sectors to the SCCM provides a basis for discovering and sharing data about the same thing, from many sources. The SCCM is relevant wherever many organizations provide services to many communities within a place. Sharing data across a city requires more than the interoperability covered by the SCCM.

3 The BSI defines a **concept model** as a *"set of defined concepts and the relationships between them, chosen to be independent of design or implementation concerns, that can be used to describe a domain."*

For example, privacy, security, integrity, availability and quality of data also needs to be considered by decision-makers, but these concerns are beyond the scope of PAS 182.

The SCCM defines a series of 27 **concepts** (22 prime concepts and 5 group concepts) that can be used to describe the entities that are typically contained in city data. The prime concepts are: Account, Agreement, Assumption, Building, Case, Community, Decision, Event, Function, Method, Metric, Object, Objective, Observation, Organization, Person, Place, Plan, Rule, Service, State and Target. The group concepts are: Abstract, Agent, Collection, Item and Resource. Each concept has been selected for relevance in describing data that is valuable to share across a city and its sectors. Each concept has a name, definition, some explanatory notes, examples of how that concept might feature in city data and a diagram to show how it is typically related to other concepts in the model. Some concepts are presented next.

The **Object** concept has the followings characteristics:

- **Definition**: A physical Item
- **Notes**: In a city there will be physical Objects that make up the technical infrastructure.
- **Examples**: Buildings, Roads, Cars, Cables, Lamp Posts.
- **Object relationships**: see Figure 7.

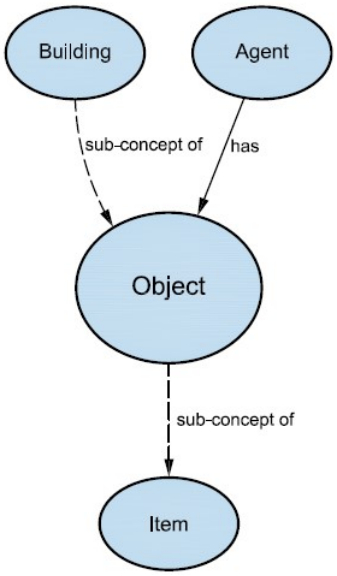

Figure 7: Object concept relationships (Copyright PAS 182, BSI 2014)

The **Service** concept has the followings characteristics:

- **Definition**: The capacity to carry out one or more Methods.

- **Notes**: A Service exists even if it is not accessed. For example, an advice hotline exists as a Service even if nobody calls it.
- **Examples**: A hairdressing service, An energy supply, A street cleaning service.
- **Service relationships**: see Figure 8.

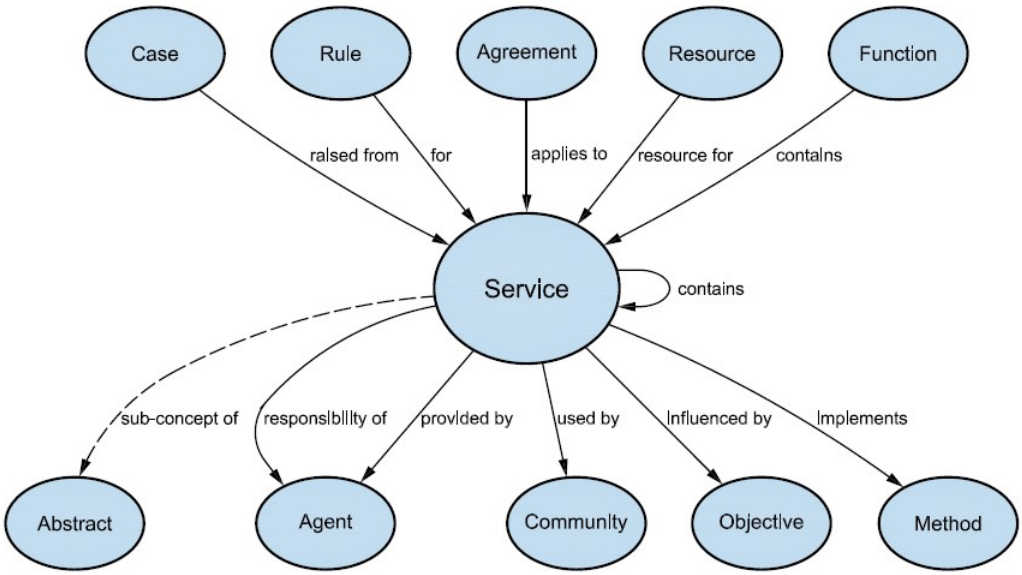

Figure 8: Service concept relationships (Copyright PAS 182, BSI 2014)

Applying the SCCM to smart city scenarios

The PAS 182 also considers some typical Smart City scenarios and proposes a view to illustrate how combinations, of concepts and relationships, can be used to share data. The Service concept, is one of the selected concepts to illustrate a data-sharing scenario across a city. The Service view can be seen in Figure 9.

In a city scenario, Services might include: energy provision, waste collection, licensing, car parking, and removing abandoned vehicles. Some of the Services characteristics and relationships in this scenario are:

- A Service is the responsibility of an Organization or an individual Person. The concepts of Organization and Person are combined into the concept Agent. The Agent providing a Service is not necessarily the same Agent responsible for it.
- A Service can be used by a Community, which might be, for example: the residents of a city or the long-term unemployed.
- As both Community and Service are sub-concepts of Item, their States can be recorded over time. For Service, this enables actual and Target values to be recorded for

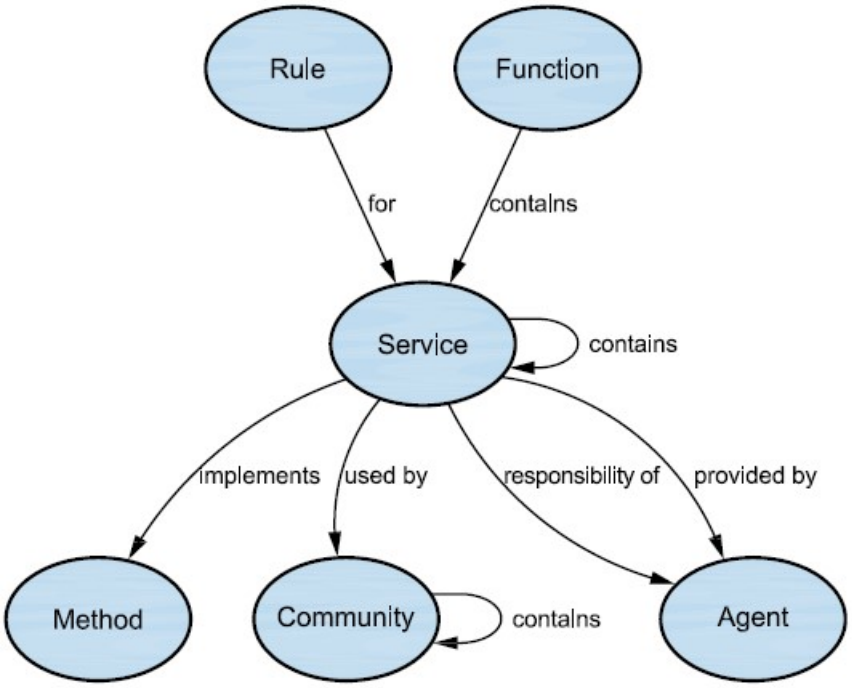

Figure 9: Service concept View (Copyright PAS 182, BSI 2014)

throughput and performance, for example: the number of abandoned vehicles reported over a period or the average time taken to remove a vehicle.

- Services are often constrained by Rules such as: legislation and terms and conditions.
- A Service implements one or more Methods, which might be reused in other Services.
- Services from many Agents can be grouped together into Functions. Function is a sub-concept of Collection.
- A Function can list the Services that serve a particular Community, for example, waste management (Function) might contain Services recycling and waste disposal, and those Services might be provided by different Organizations within the city.

In conclusion, the SCCM can be applied to a variety of unstructured and semi-structured data streams as well as the structured data which currently powers many cities and organizations. It also can be used to:

- Catalogue data holdings from different organizations, leading to improved discovery and reuse of information;
- Promote definitive and authoritative identifiers and categorizations as reference information for each concept against which city data can be harmonized and joined up;

- Agree data standards for specialisms within a concept that are of particular interest to a city;
- Understand datasets from other sectors;
- Construct a local data ecosystem where data can be contributed and consumed by different organizations and people for a city.

PAS 182 lists a number of ways that the SCCM can be applied to guidance provided in PAS 181, more specifically the key cross-city governance and delivery processes, so both documents should be used together.

2.6.3 *Process Standard: PAS 184*

PAS 184 - Developing project proposals for delivering smart city solutions provides practical, "how-to" advice, mentioning good practices identified by participants in Smart City projects from the public, private and voluntary sectors. The advice is structured into three main components:

> **Component A – Smart thinking**: how to challenge traditional ways of doing things within the city, identifying where solutions could deliver change in city activities;
>
> **Component B – Smart practices**: how to develop projects that:
>
> - Deliver Smart City solutions in practice;
> - Minimize risks while achieving the desired impacts of the solution;
> - Are consistent and ensure security needs; and
> - Optimize contributions towards city goals in the future.
>
> **Component C – Smart measurement**: how to build measurement and evaluation into the project, in ways that support successful delivery of the solution; Enables effective communication to city stakeholders of the solution's impact; and Provides actionable learning for future projects in the city.

The three components are illustrated in Figure 10. There are interactions between all the good practice components which means that the starting point for two Smart City projects may be different and may have different implementation paths, depending on city's priorities, context and nature of the project. Therefore, PAS 184 is supposed to be used in a modular way, providing a consistent structure that helps the connection with the other components. Also, each one of the three components has a description with a summary of recommendations and some examples of application in real cities, when appropriated. Some of the examples, in the [A]Smart Thinking component, are:

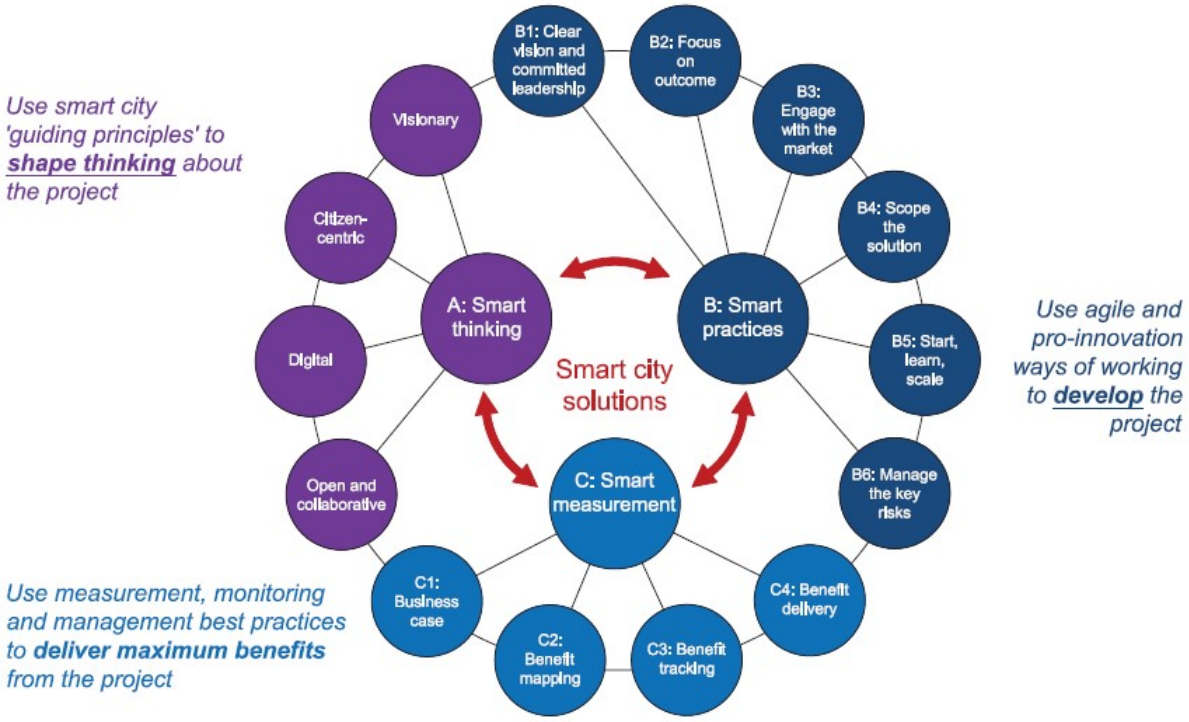

Figure 10: Overview of the components of PAS 184 (Copyright PAS 184, BSI 2017)

Case study: reducing costs through empowering citizens to self-serve: In the town of Eastbourne the local government developed a new smart phone application that enables citizens to report problems direct to the contractor. Resolution times and costs have gone down and citizen satisfaction has increased.

Case study: reducing demand through behavioural change: With the aim of increasing the environmental awareness, by promoting recycling, 16 schemes in the United Kingdom gave citizens reward points for use in local shops or to support community projects in 2014. The results found an average 8% increase in recycling performance and 3% reduction in landfill areas. All this was achieved with lower cost schemes when compared with traditional communication strategies.

Case study: reducing costs and improving performance through real-time matching of supply with demand: The city of Bournemouth used a route optimization software to increase the performance of waste collection in real time. Results include savings of £300k and 4% savings in staff costs.

Case studies: collaborating to reduce costs of waste collection: Four South Coast towns in the United Kingdom have agreed in a ten year waste collection and street cleansing service

with integrated systems. Eastbourne alone presents annual savings around 25% in these areas.

In conclusion, PAS 184 provides guidance, illustrated with case studies and examples, on how good practice described in other BSI Smart City publications can be applied when developing a Smart City project. Also in this document is presented a set of components that might help developers in the starting point of the program so, PAS 184 should be used not only by city leaders but also from parties of the public and private sectors.

2.7 TECHNICAL STANDARDS OVERVIEW

The technical standards level covers the technical specifications that are needed to implement Smart City products and services so that they meet the overall objectives. Since the range of Smart City activities and projects is too wide, from water pipes to people, undergoing energy, buildings, lighting and government services, it's almost impossible to cover all standards in this level. Since the main objective of this dissertation relies on the presentation of a high level Smart City guideline, the technical standards represent the less relevant level of standards, but their mention is important.

Smart Cities Preliminary Report 2014 is a *Technical Report (TR)* made by ISO/IEC JTC 1, where is presented a table that gives an overview of the major international standardization initiatives on Smart Cities. Some of the groups, identified both in Figure 4 and in this report, and some of their standards are:

- **IEC / TR 62357** - Power system control and associated communications;
- **IEC 61850** - Power Utility Automation;
- **IEC 61968** Common Information Model / Distribution Management
- **IEC 62351** - Security Standards for the Power System Information Infrastructure;
- **IEEE 1901** - Broadband over Power Line Networks: Medium Access Control and Physical Layer Specifications.
- **IEEE 2030** - Guide for Smart Grid Interoperability of Energy Technology and Information Technology Operation;
- By **ISO/TC 163 and ISO/TC 205**
  - **ISO 12655** - Energy performance of buildings: Presentation of measured Energy use of buildings
  - **ISO 13153** - Framework of the design process for energy saving single-family residential and small commercial buildings

- By **ISO/TC 223: ISO 22301** - Societal security: Business continuity management systems – Requirements; and
- By **ISO/TC 241: ISO 39001** - Road traffic safety (RTS) management systems: Requirements with guidance for use

As can be seen, the technical standards scope is immense, covering areas from Smart Buildings to Smart Grids.

2.8 OTHER TYPE OF STANDARDS

There are other type of standards that don't fit any of the presented levels but its importance can not be denied. When Smart City projects are discussed and planned, where local governments and the various stakeholders debate the best options to take, the use of a common language is essential.

The **PAS 180 - Smart Cities Vocabulary**, is one example of a standards that don't fit any of the levels previously presented but should be taken into consideration when planning Smart City initiatives. This standard, defines terms relating to sustainable development in communities, smart community infrastructures and its related subjects. The many parties involved in developing Smart City projects should have the same definition of some words that include:

- **Integration:** The process of combining software components, hardware components, or both into an overall system;
- **Metric:** Defined measurement method and measurement scale;
- **Monitoring:** Act of periodically checking processes, equipment and environment in order to detect any changes;
- **Resilience:** Ability of a community, city, organization or system to resist being affected by disruptions; and
- **System:** Set of objects or processes working together as parts of a mechanism or an interconnecting network;

It can be concluded that the three level standards presented by the BSI should be complemented with the right usage of other standards.

2.9 CASE STUDIES AND SUCCESSFUL SMART CITY INITIATIVES

As presented in section 2.6.3 (Process Standards: PAS 184), there are many study cases revealed in various published process standards. Although each city is unique and Smart

City initiatives should reflect the needs of the local citizens, local governments can look at other cities with successful Smart City programs, study their model and adapt it to their own city.

2.9.1 *The importance of Data*

Within the next twenty years, most of the data that will be used to understand cities will come from digital sensors [33]. So, a key factor in a city becoming smarter is its ability to exploit the power of data. The Smart traffic management in Stockholm is one example presented in Smart cities overview PD:8100, published by BSI. In this case, the real time information about the cities traffic status is presented to citizens who sent a text message listing their location and desired destination, and received another message with the best moving option to take.

> **Case study: Smart traffic management in Stockholm -** Researchers at KTH Royal Institute of Technology in Sweden used IBM's streaming analytics technology, to gather real-time information from the *Global Positioning System (GPS)* devices on 1500 taxi cabs in the city and aim to expand this application to gather data from delivery trucks, traffic sensors, transit systems, pollution monitors and weather information. The generated data is processed using IBM's software, giving the city and residents real time information on traffic, public and private travel times and the best available commuting options.
>
> As a practical example, a resident could send a text message listing his location and desired destination. The technology would instantly process the real-time traffic and weather information and provide travel times via car, taxis and public transports, giving the user an accurate and instant view of the fastest way to get to their destination.
>
> The congestion management system has reduced traffic in Stockholm by 20%, reduced average travel times by almost 50%, emissions by 10% and the proportion of green, tax-exempt vehicles has risen to 9%.

In order for this to happen, the city should be instrumented. Every opportunity should be taken to deploy sensors, CCTV cameras and other devices at strategic points around the city, to allow the collection of useful data about the city life. Also, data collected by different agencies should be public, easy to aggregate, visualize and access, always respecting the privacy and security of the citizens.

2.9.2 *The importance of People*

"The key challenge around smart cities is not technological but about people" (PD:8100, p.10). Since citizens represent the main Smart City stakeholder, city leaders need to develop new strategies that can help to coordinate the everyone's activities around common goals, leading to effective solutions where everyone wins. With the main objective of making a city smarter, city leaders and organizations should use the new tools, provided by technology and data, to put in place better policies, services and infrastructures to citizens, communities and local businesses. Also in PD:8100, is presented a Case study about the city of Glasgow where citizens were challenged to share their electrical bills with the government with the objective of obtaining an energy efficiency report on their own properties.

> **Case study: Useful data through partnership with the citizen -** Glasgow city council planned to develop a 3D software model of the city's buildings, with data on energy consumption, fuel types, building type, construction type, building age, roof type, among others. The model would allow energy planners to look at all aspects of energy consumption, correlate them with the building data, and use the resulted information to plan better energy solutions for the city life.
>
> From previous experience, it was known that it would not be possible to get access to energy consumption data at a domestic level, due to privacy issues. So, the local city council linked the model to a public a website that encouraged citizens to input their energy consumption and building data in return for a energy efficiency report on their property, produced automatically using a software simulation tool. The report provided them with a list of possible interventions that could be applied to the building to increase its energy efficiency.

In this case study, citizens could become smarter in the management of their own home electric consumption and also help the city as a hole to be better managed, since this is a comparatively low-cost way for the city government to gain useful information about buildings and energy consumption, creating a win-win situation. Usually, citizens may expect the local authority to take on the overall responsibility around the city, but many may be happy to help by providing useful information and feedback, especially if they gain something back in return.

2.9.3 *The importance of Collaborating with the citizen*

Another way that enables the engagement of local governments with their citizens is by using their smartphones, since it can be used as a sensor to provide data to the city council. The use of the smartphone means that the location of the problem can automatically be

provided and it is also easy for the citizen to send a photo, or a report, to show the extent of the problem, by simply using a mobile application. Also in PD:8100, is presented the case study about the city of Boston, where citizens were challenged to use their smartphones to help improve street roads [34].

> **Case study: tackling potholes in Boston -** A project of the Boston Mayor's Office of New Urban Mechanics, Street Bump, helps residents improve their streets. Volunteer citizens can download the Street Bump application into their smartphone and use the phone's sensors to collect road condition data while they drive. Street Bump uses two of the smartphone's sensors: the accelerometer and GPS. The sensors can detect bumps that are automatically uploaded to the application database. The bump location can them be immediately mapped by the city council and local authorities can undertake appropriate actions.

The key to making this work is to provide immediate feedback as to what the local authority is planning to do about the problem, with a deadline as to when it will be fixed, and to inform the citizens when the problem has been dealt with. The driver that used the application, can be automatically notified when the bump is fixed. This is not only a comparatively easy way to get useful data and information from the city roads, but it also helps build a positive relationship with the citizen.

2.9.4 *A reward system: CityPoints Cascais*

When local governments take into consideration the importance of data, the importance of people, the importance of collaborating with the citizen and combine this three factors with a good services, great initiatives and projects can be implemented. One example of this is the project **CityPoints Cascais** [35], winner of the Digital Innovation award at the Global World Summit Awards 2018 [36], implemented by the city council of Cascais. This initiative consists in an mobile application which aims to promote sustainable practices and recognize citizens who actively contribute to local sustainability. This initiative recognizes four big areas where citizens can exercise good practices: Environment, Citizenship, Social Responsibility and Mobility. As the user exercises good practices in these four areas, he gets points in his account. The examples of behaviours that are rewarded with points can be seen in Figure 11.

Points are given by reading the QRcodes spread by the city and placed in the key locations. Also, the application offers a map with these locations where citizens can preform the sustainable activities. With the earned points, users may pick vouchers offered by the network of local partners and these vouchers can be used to obtain services or products like discounts or offers in books, free participation in municipal events and free entrance in

Figure 11: Examples of behaviours that are rewarded with points

concerts and museums. If an user does not want to use a certain voucher, it can be shared with another user or donated to a social cause that the community wants to support.

With this initiative Cascai's city council intends to impact the citizens by promoting ecological behaviors, social concerns, social participation, sense of belonging and create partnership among local actors. In return, these behaviours bring positive impact to the city of Cascais like increasing sustainability, resilience, optimizing and saving resources, community development, local solidarity and a push in economic and social environment.

2.9.5 *Smart Initiatives for smart returns*

The lack of funding might be a major obstacle in terms of implementing Smart City initiatives. One possible resolution to this problem might be use of technology to achieve great savings. In the Guide to Smart Cities, published by BSI, is presented the example of the city of Barcelona that was searching for ways to avoid economic stagnation, after the 2008 recession [31].

> *"In Barcelona, the city's parks use technology to remotely sense and control park irrigation and the water in public fountains. This program alone increased the city's water conservation by 25%, saving around 555,000£ a year."*

By investing in technology, the government saved almost half a million dollars per year. Even if the investment was greater than that, after a few years the savings would make up for the initial investment.

2.10 SUMMARY

Building a Smart City is a complex task, but one common denominator can make things simpler for city's decisions makers: standards.

In this chapter were presented some of the main standards in a Smart City scope. Standards contain best practice guidance and expert knowledge that ensure quality and performance, providing a common language that should be used when the different stakeholders propose and implement Smart City initiatives. The good use of standards can let local governments compare solutions and choose the best ones for their needs, while providing valuable guidance for city life. As a result, standards can help reduce risks, cut costs and make it easier to manage cities, in a more effectively way.

From the in depth study of the standards, a list of good practices can be made. This list takes into consideration not only the standards recommendations but also some of the successful Smart City initiatives already studied or implemented. So, some of the good practices that can help cities grow into a smarter and sustainable city are:

- Before implementing any project, a strategic approach should be delineated. This includes creation of teams, identification of the areas of intervention, review of national and international policies, gathering inputs of as many stakeholders as possible and definition of deadlines and objectives;
- Smart and sustainable initiatives should be centred around the needs of citizens and local businesses;
- The deployment of sensors, wireless security cameras and other devices should happen in every opportunity, depending on the initiative;
- Data that comes from these sensors should be worked on and transformed into information to be available in real time and to everyone, via open platforms, in a measurable way;
- Collected data should be correctly stored and catalogued, in a way that data from different organizations has the same language and is interpreted in the same way;
- The conditions for ensuring a free access to the public information should be guaranteed by the city's leaders, like free internet access;
- Decision makers must ensure data integrity and availability, taking into account the fact that critical and personal data should be secure;
- Local governments and organizations should collaborate with citizens to reduce costs by empowering citizens to self-serve and promoting behavioural changes;

- Citizens with regular sustainable practices should be recognized and rewarded; and
- City's decision makers should take into account that by investing in technology, great savings can be achieved in the long term.

The list of good practices should be taking into account when the Smart guideline is proposed. Also from the study of standards it's possible to identify some of the crucial stakeholders that Smart City programs should be influenced by, in order to increase the success rate of the project. Some of the main stakeholders include citizens (inhabitants, workers and tourists), governments (city leaders and planners), local businesses owners and local authorities.

2.11 RELATED WORK

Since the definition of Smart City can still be debated, there are several frameworks that try to answer to the main questions about this environment, identifying critical factors and stakeholders of a traditional Smart City initiative.

In *Current trends in Smart City initiatives: Some stylised facts* [37], are identified and classified the six main domains of a Smart City: Natural resources and Energy; Transport and Mobility; Buildings; Living; Government; and Economy and People. In this study, analyses have been conducted in order to understand the relationship between these various domains and the results show that the patterns of any individual Smart City depend, to a great extent, on the local context factors. The retrieved conclusions enhance that local policy makers should try to identify and understand these context factors in order to shape appropriate strategies for their cities and "bottom-up" approaches should be considered instead of resorting in deploying complex technological platforms. As an example, citizen's smartphones can be used to collect real time data rather than a complex infrastructure of sensors.

Both dimensions and conclusions match with some of the good practices imposed by the main Smart City standardization: each city is unique having its own needs and priorities; Smart City initiatives should be centred around the needs of citizens and not around technology; and city leaders should engage and collaborate with citizens to reduce costs.

Although the conclusions drawn from this study point in the same direction as the good practices imposed by the standards, the introduction of indicators, that can measure and quantify the smartness of a city, are not specified. As identified in ISO 37120 and PAS 181 (ISO 37106), smart cities programs and visions should be measurable in a way that allows comparison between cities and regions.

In *Understanding Smart Cities: An Integrative Framework* [38], are identified eight critical factors of Smart City initiatives that form the basis of a framework that can be used to study and determine success factors of Smart City programs. These factors are: Management and organization; Technology; Governance; Policy context; People and communities; Economy; Built infrastructure, and Natural environment. Authors defend that each one of these factors should be considered when examining Smart City initiatives. Additionally, these set of factors are also presented as a tool to support the understanding of the success of different smart city initiatives implemented in different contexts. Presented factors are divided in two different levels: Outer factors (Governance, People and communities, Natural environment, Infrastructure, and Economy) that, in some way, are influenced more than influential Inner factors (Technology, Management, and Policy) before affecting the success of Smart City initiatives.

All the presented dimensions match some of the areas mentioned in the Smart City standardization but the main conclusions of this work prove that the citizens and their communities had been neglected on the expense of technology and policy aspects of smart cities. As the authors state, citizens should be allowed to participate in the governance and management of the city, since the Smart City standards PAS 181 (ISO 37106) and PAS 184, defend that initiatives should be centred around citizens and local businesses.

3

EVALUATION OF STANDARDS EFFECTS ON SOCIETY

This chapter presents the study carried out after the identification of the good practices imposed by the standards. In the first place, a survey of to the urban population is presented, in order to understand which are their priorities in the Smart City scope. Secondly, an interview with a local government councillor advisor is presented, with the objective of understanding which initiatives are or have already been implemented in order to transform the city of Braga in a Smart City.

3.1 SURVEY CONTEXT AND OBJECTIVES

"What is the city but the people?"

William Shakespeare, Coriolanus

To ensure that Smart City projects are successfully implemented, it is essential to understand the motivations of urban population, since they represent one of the most important stakeholders group in any city or Smart City environment [29]. So, these projects should reflect the needs of the citizen community, making their opinion crucial, since intelligent and modern infrastructures serve little purpose if there are no people around to use it. In order to identify the citizen's priorities and to understand if the LabSecureIot initiatives match those priorities, a survey was conducted.

The LabSecureIot (presented in the Section 1.2) aims to create partnerships with local governments and companies. One of the laboratory's projects is the development of small and cheap devices that can be embedded in public transports. These devices, should integrate a tracking system, such as GPS, communication capabilities, such as Wi-Fi or GSM, and must be built with sensors that acquire information from the environment, such as humidity, temperature and air quality. An image of one of these sensors can be seen in Figure 12. The captured data should then be sent to a central server, also developed by LabSecureIot, that integrates all the data, processes it and provides appropriate information services for the end-user in real time. Since buses and garbage trucks cover much of the

city area, the resulting information could contain not only levels of the city's air quality but also information about traffic, by comparing the time that a bus is not moving outside of a bus stop.

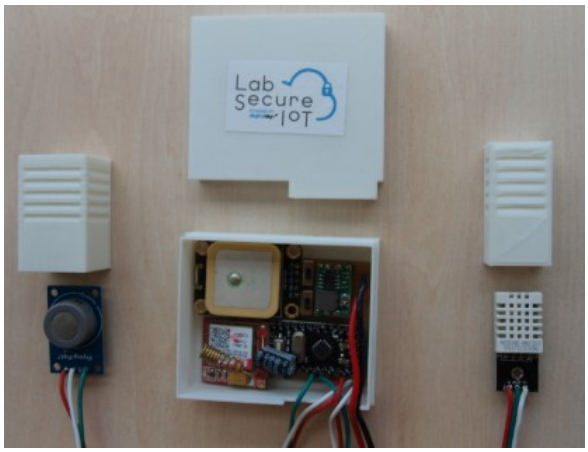

Figure 12: Example of a sensor coupled in the LabSecureIot

This project is being developed in cooperation between the laboratory and companies responsible for public transportation and waste collection, in the cities of Braga and Guimarães, and crosses two Smart City areas: the Smart Mobility and the Smart Environment (see Figure 2). So, it is crucial to understand if citizens have interest in using real time information about air quality, car traffic, and public transports and garbage trucks positions. Therefore a survey was conducted to the urban population which had three essential objectives:

1. Understand the main motivations and priorities of citizens, identifying if the areas of environmental sustainability and mobility match those priorities;
2. If there is an interest in Smart City projects in those areas, how would citizens like to access the various types of information generated from these initiatives; and
3. Understand the business model that would please not only the urban population but also local governments.

The survey was conducted digitally, using the Google Forms tool. As of 4th of September 2018, 210 questionnaires were answered in total. The age distribution of survey respondents can be seen in the Appendix A, Figure 25. Adults between the ages of 18 and 45 represent around 93% of the inquired population, allowing to conclude that citizens in this age group might be the most interested in Smart City initiatives, been more open to the insertion of technology in everyday life.

All the questions were carefully prepared, trying to be as clear as possible to the inquired, allowing only yes or no answers with the exception of one question.

3.2 SURVEY QUESTIONS AND ANSWERS

In this section will be presented only the main questions asked in the survey, that were planned to give answer to the three essential objectives proposed above. In order to clarify its presentation and analysis, each question has been placed into a group, making 4 groups of questions in total. The complete survey, containing all questions and answers, can be seen in the Appendix A.

3.2.1 *Group 1: Identification of Priorities*

The first group of questions had the main objective of understanding which Smart City Areas represent priorities for the local citizens, trying to identify which services or applications would citizens use, if available. These questions meet the Smart City Areas of the projects that were being developed in the LabSecureIoT. This group consists of a total of 7 questions:

"Would you use a service or application capable of presenting real time information about:

1. *The air quality status in various parts of the city?*
2. *The temperature and humidity of the air in several points of the city?*
3. *The traffic status in the city?*
4. *The status of parking slots (free or busy) of public parking, in strategic points of the city?*
5. *The average noise level in various parts of the city?*
6. *The location of public transports and the estimated time of arrival at a certain location?*
7. *The location of garbage collection vehicles and the estimated time of arrival at a particular location?"*

The answers to these questions can be seen in Figure 13. By analysing the responses some conclusions can be made, such as:

1. The surveyed citizens have high interest in using services that give real time status about the traffic, public parking slots and public transports (questions 3, 4 and 6), since in all 3 of these questions over 92% of the inquired answered in a positive way;
2. There is many interest in services that give real time status about city's air quality, temperature and humidity (questions 1 and 2), with more than 70% of the inquired answering in a positive way;

3. There is some interest in using applications that give information about the city's noise level, (question 5 with 51% of positive answers) and the location of garbage collection vehicles (question 7 with 49% of positive answers).

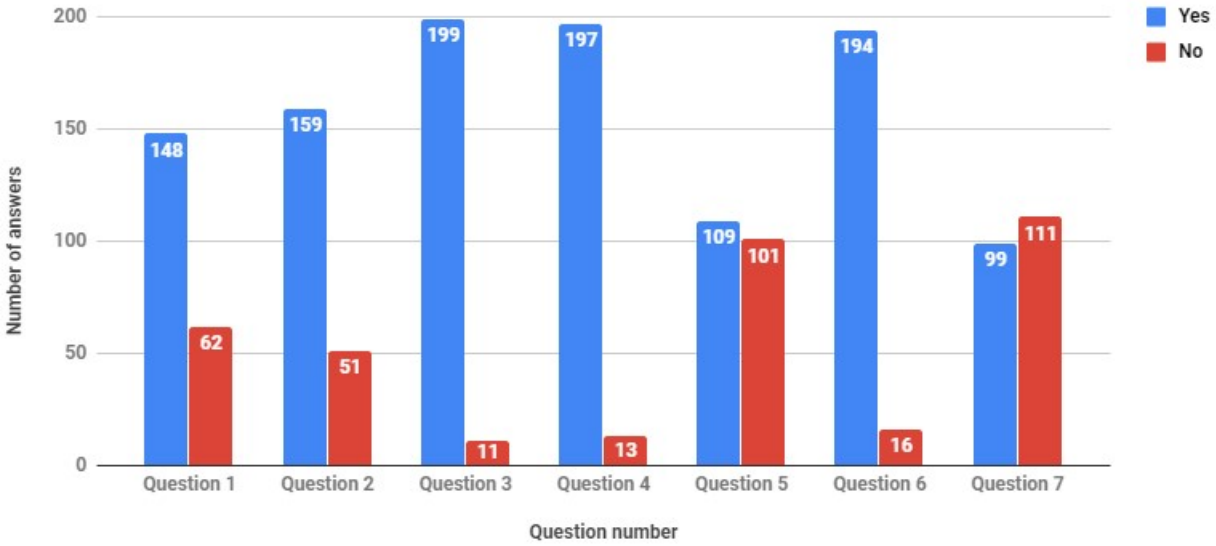

Figure 13: Answers to the seven questions about the Smart City status and variables

Following the previous seven questions, a mislead question is presented, allowing to understand not only if the inquired considers monitoring of air quality in a city important but also if the respondent contradicts his previous answers. Therefore, it was asked *"Do you consider monitoring of air quality in a city important?"* The answers to this question can be seen in Figure 14.

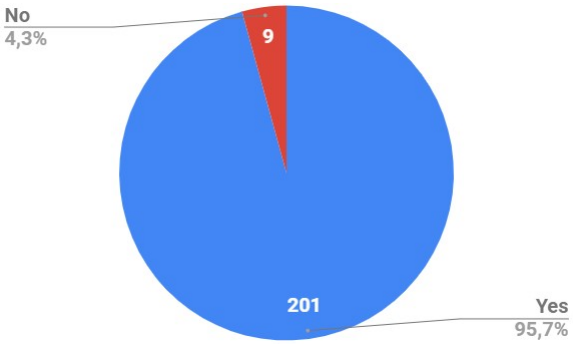

Figure 14: Answers to the question about the importance of monitoring the city's air quality

The answers obtained in this group of questions show that there is a interest in using applications that cover the areas of the Smart Mobility and the Smart Environment, allowing to conclude that the projects studied and developed by the LabSecureIoT match with some of the population's areas of concern.

3.2.2 *Group 2: Information Display*

The second question is the only one with multiple choices, allowing the surveyed to select one, two or three hypotheses, and has the main objective of understanding in which way the information should be displayed to the end users. The decision of allowing multiple answers, lies in the fact that each type of information has it own nature and could be displayed in multiples ways. It might make sense if the information about city's air quality status or public transports locations are displayed in public panels, in strategic places, but also in a mobile application so, multiple answers were allowed.

The question asked was: *"Considering the cases previously presented, how would it be more interesting to observe these types of information? (Multiple answers can be selected)"*. The answers to this question can be seen in Figure 15.

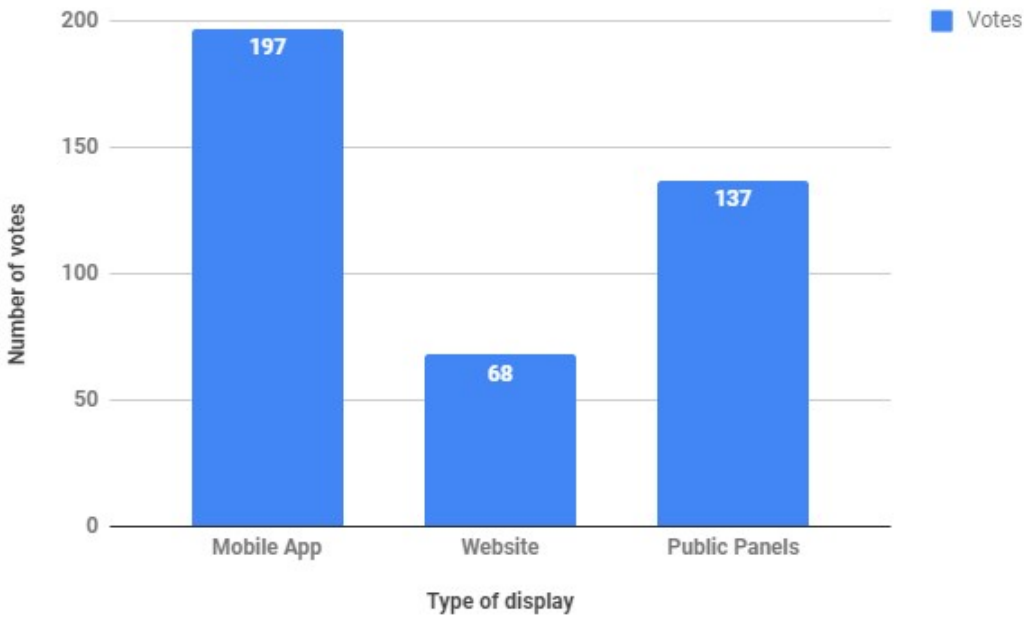

Figure 15: Answers to the question about display of the information

By analysing the responses some conclusions can be made. 197 (93,8%) of the answers had the mobile application selected, suggesting that with the Smart City initiative comes the need of also developing a mobile application where the information is made available at any time. This might require not only a team of mobile developers but also the infrastructure to support mobile applications such as servers, network coverage and databases. 68 (32,4%) of the inquired think that a webpage, that aggregates and displays the information, could be a solution but, when compared to the other two choices it does not represent a priority. 137 (65,2%) of the surveyed think that public panels should be used to display these various

types of information. As an example, small displays in the bus stops can show not only the expected time of arrival of buses but also the local air quality status.

3.2.3 *Group 3: Business Model*

This group of questions has the main objective of understanding if the urban population has interest in paying for Smart City applications that provide real time information about the city status. Implementing Smart City services and applications might be expensive and unbearable for local governments, so some type of monthly fee might be imposed to citizens. An example of a monthly fee is the *"Contribution to Audiovisual"* on electricity bills, that is intended to finance the public service of broadcasting and television [39].

Trying to understand if citizens are available to pay a small monthly fee, like it happens in the audiovisual services, the first questions asked in this group was: *"Like the audiovisual services, would you be willing to pay a symbolic monthly fee so that this type of information is publicly available?"* The answers to this question can be seen in Figure 16.

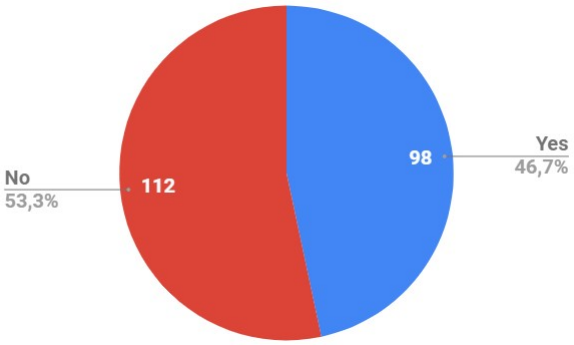

Figure 16: Answers to the first question about the business model

Analyzing the answers obtained can be concluded that there is some hesitation in paying, even a small amount, to obtain public information about the city's status, leading to other alternatives to be equated.

An alternative to pay a monthly fee could be the purchase of a mobile application, with a fixed cost. The question asked was: *"If you answered "no" to the previous question, would you be willing to buy a mobile application that would provide this type of information?"* Although the objective of this question was to identify an alternative to the monthly fee previously proposed, all the inquired could respond this question without answering "no" to the previous one. The obtained results can be seen in Figure 17.

For the majority who answered this question, the purchase of a mobile application doesn't represent an alternative method of payment to a symbolic monthly fee.

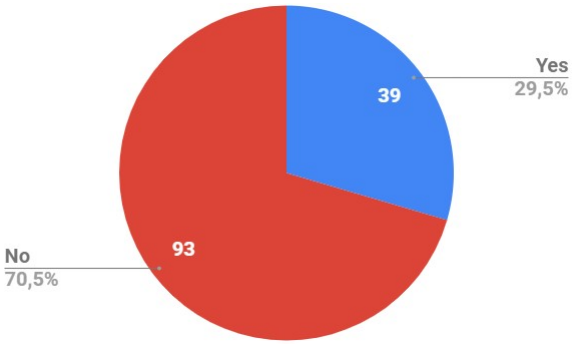

Figure 17: Answers to the second question about the business model

3.2.4 *Group 4: Reward System*

The last question of the survey had the objective to understand if citizens would feel more attracted to use the types of services proposed above if they were rewarded when practicing urban sustainable activities. This reward could represent free entrances in local museums or discounts in concerts or local activities. Therefore, the question was: *If a Smart City point system is implemented, where citizens are rewarded for doing urban sustainability activities (recycling, using public transport, etc.), would you feel more attracted to these types of services? (The points could represent discounts in the daily life of citizens)*. The responses to this question can be seen in Figure 31.

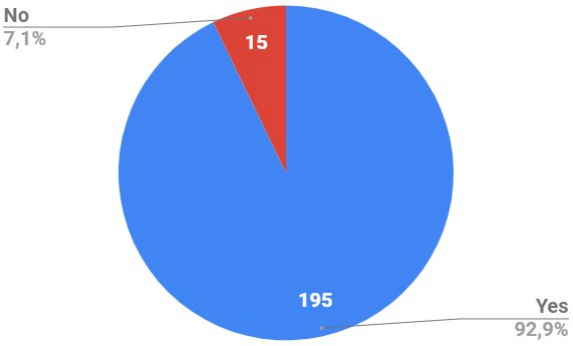

Figure 18: Answers to the question about the reward system

92% of respondents think that a reward system makes the Smart City services more attractive and should be given strong consideration when implementing Smart City programs.

3.3 SURVEY CONCLUSIONS

This survey served to understand citizens' motivations regarding Smart City projects, how they would like to access the generated information and also to start studying a business

model that guarantees the success of the Smart City project. Once finished, it is possible to draw conclusions that complement the good practices implicit in the Smart City standards.

By carefully analysing the results obtained, it's possible to conclude that:

- In general, citizens are concern about the city's air quality;
- The Smart Mobility dimension represents the biggest area of interest of the inquired urban population. Smart City projects covering this dimension have high chances of being accepted and used by citizens;
- The Smart Environment dimension represents a priority to the inquired urban population. Smart City projects covering this dimension have good chances of being accepted and used by citizens;
- Generally, citizens prefer to access information through mobile applications. This may require not only good and free network coverage across the whole city area, but also the services that guarantee the application's proper functioning and security;
- Governments that want to implement Smart City initiatives should take into consideration the fact that the urban population is sceptical in paying for these types services, so a sustainable business model needs to be studied;
- To convince citizens to engage in sustainable practices, governments should implement a set of rewards to compensate citizens or small business that undertake sustainable decisions.

3.4 Interview overview and objectives

Previous sections presented some of the main motivations of the citizen community, defending the idea that without smart and connected people, there are no smart cities. There will also be no smart cities without the effort and dedication of local and national governments so, the proposed Smart City guideline can contain not only the best practices imposed by the main adopted standards but also the motivations and needs of citizens and local governments.

Therefore, an interview was conducted with the main objective of understanding the main priorities but also the obstacles and difficulties of implementing Smart City projects by a local government. This interview was designed to focus on 3 essential points:

- Understand the vision of a local city council regarding the Smart City thematic;
- Understand the priority areas and Smart City projects that the city council would like or will implement;

- Know the opinion of the city council on the creation of a "control station" capable of collecting, organizing, monitoring and alerting, in real time, the various types of information generated in a Smart City.

With the main objectives of the interview identified, someone with power of decision and working in a local government was needed to conduct the interview.

3.4.1 *Choice of the Municipality and the Interviewee*

Since the author of this dissertation is a citizen of Braga, the choice of the interviewee fell into João Luís Barros, Advisor to the City Councillor João Rodrigues, whose functions are the Management and Conservation of the city's Public Space and Management and Maintenance of Municipal Installations in the city of Braga. The reasons why João Luís Barros was a primary choice as an interviewee were the fact that:

- He is someone who works directly with the City Councillor and therefore his opinions have influence in the decision making of many projects and initiatives of the municipality;
- He does many of the fieldwork, knowing in first hand the problems and limitations of citizens;
- By working in the local government, he has a greater perception of the government limitations and priorities;
- Some of the initiatives that try to turn the city of Braga into a Smart City have been proposed by him and his office.

With the candidate's choice concluded, it was possible to arrange an interview where the topics previously defined were debated.

3.5 INTERVIEW. QUESTIONS AND ANSWERS

The interview was held in the city council headquarters of Braga on August 3rd, 2018 and all questions were asked by the dissertation's author. The main topics discussed are presented next.

1. Q – **How do you describe a Smart City?**

   A – I see the Smart Cities as the natural path that cities have to follow. We need to embrace and use the new technologies to improve the way of life in cities, especially

for our citizens. I see a Smart City as a city where everyone is connected and everyone knows what is happening, in real time, in the city.

2. Q – **Have any initiatives been taken to turn Braga into a Smart City?**

A – Within the Smart City scope and since we are responsible for the management of the public space, which is everything that involves sidewalks, streets, urban equipment and garbage collection, we decided to create an application. After meetings with our teams and several companies, we concluded that the municipality of Braga suffered from the existing bureaucracy. When something was wrong, the citizen could present a complaint to the city council via Facebook's chat, by email or at the city council's desk. But these occurrences had the bureaucratic part: between the complaint and the resolution of the problem the citizen had no idea of what was happening. So, in this application, citizens can take a photo with georeference, and report the problem, for example, a hole in the street, a broken drinking fountain or a broken light post. All municipal technicians have access to the back office of the application and filter the occurrences that are under their control. Users can access the application without reporting a problem, but to see the status of all complaints made: if the problem has already been dealt with (green status), if the problem is being processed (blue status) and if the problem is still not being addressed (red status), all to avoid duplication of complaints. Once the reported problem is solved, the user that made the complaint receives a message reporting it.

With this project we were able to: remove the bureaucracy part, to turn the citizen into a fiscal agent, since it was the citizen who detected and reported the problems, and we also managed to show the citizens which processes the council is dealing with.

3. Q – **Which are the main problems of the city?**

A – Before turning Braga into a Smart City it is necessary to identify the problems that still remain in the municipality, which is not only the downtown area. For example, the safety of people, the huge traffic flow that Braga suffers, the access to city's historic center, excess of waste and traffic congestion are some of the main problems of the municipality. Some applications such as smart crosswalks or smart traffic lights might help in solving these traffic problems.

4. Q – **So, would you say that mobility is the priority area of intervention?**

A – Yes! Mobility is a priority for the municipal executive and is something that Braga has to improve on. When we look at other cities such as Porto and Lisbon they are already in an advanced state in the conditions they give citizens who intend to move by walking or riding their bicycles. We already have the ecological track but we need to give more conditions to the cyclists and pedestrians, while changing some of the city's access roads.

5. Q – **Which other sustainable projects would you like to implement in the future?**

A – We had several meetings with the councillor and other entities, suggesting the installation of panels under each traffic light that offer complementary information to drivers such as meteorology, air quality status and the advertise of municipal events, which is something that I want to improve and energize because I notice that we are still somewhat behind when compared with other major national and European cities. We have to abandon the advertising panels with paper and digitize the city more and more, so that the information arrives with more quality and in less time to the citizen. We also want to create a network of interactive digital panels that would reveal all the municipal events. These panels would be strategically placed throughout the city and in some places of interest such as the train station, where many tourists arrive.

Braga has another problem that I forgot to mention: the fact that is already built. Our desire is to plant large trees in the downtown area but the foundations are already built with tunnels or other infrastructures such as gas or water and the tree roots would damage these infrastructures. Other public areas such as the *Campo da Vinha* are like ovens in the summer and it is something that I want to change.

The light system is something that we also want to improve. Nowadays we have the halogen system and the LED system. It makes sense that Braga once and for all remove all halogen lighting and be totally illumination with LED technology, which will take time and it will be expensive but the municipality wants to take opportunity in the funds destined to finance some of these activities.

6. Q – **Is there interest in creating a data centre that aggregates, manages and allows real-time monitoring of all the information generated from the Smart City initiatives and projects?**

A – The interest exists, but not in the near future. But it's indeed a solution that must be addressed. Imagining an office with several computers, where technicians perform the control and mapping of the city's information it's indeed a good initia-

tive because the data is processed in real-time and some troubles could be solved in a faster way. An example of this is the problem of accessing to the city's historic downtown area. At this moment, there is a pin that locks and unlocks the cars passage and, when a citizen intends to drive by, needs to perform a call with a mobile phone. If that number is in our database, the pin drops and the car can pass. I would like to replace this system with a license plate recognition system using CCTVs, allowing the passage to cars with access but also priority vehicles. Since the Civil Protection, INEM (National Institute of Medical Emergency), PSP (Public Security Police) and the municipality are interconnected, we have the registration number and mobile phone number of each one of its vehicles. But nothing guarantees that in an extreme situation all these contacts are enough. As an example, that happened in past, in which an ambulance came from another region, the access was difficult because the mobile phone number wasn't in our database. If there were a control room, with 24-hour technicians, the problem would be solved in a few minutes.

Another example that happened recently was a car accident that occurred due to the malfunction of the traffic lights in one of city's main avenue. This could also be avoided if in such control centre there was a technician that detects the malfunction in real time and could proceed immediately to the problem's resolution.

7. Q – **Are there any prospects of sharing information about the real time position of public transport and garbage trucks?**

A – Some bus stops have digital displays that indicate the number of the bus and the estimated time of arrival. It does not exist at all stops and is something that has to be extended. The Smart Cities are exactly that, to help people's daily lives and to give them information. We are also starting to take sustainable measures in the public transportation, by acquiring new propane-fuelled vehicles, since electric buses are still very expensive.

Regarding garbage collection, at this moment, new containers are being installed that aim to finish with the garbage placed on the streets. AGERE (Water, Effluents and Waste Company of Braga) is implementing containers that shall be spaced less than 100 meters from houses. These containers avoid bad smells and bad environment, since they have been designed to be easily cleaned by a truck, specially dedicated to the function. I do not know if AGERE has thought of this, but it makes sense for the containers to automatically notify the company of their filling percentage. This application also started a bit on our part because it also required us to create the conditions for the containers to be installed.

8. Q – **There are no Smart Cities without governments, but it may also be necessary to motivate the population to use and take advantages from all this technology. What do you think about the idea of implementing a points system that rewards citizens who take sustainable activities? Other initiative like CityPoints Cascais had success in implementing this method.**

A – Cascais is different from Braga. In Braga, unfortunately, there is still some lack of civility. Everyday we see cars parked incorrectly on the sidewalk and in the middle of the street, so I don't know to what extent people would join a points system... But it's a funny idea. It's something to consider. We always have to know our own universe. For example, I believe that even with the container system that AGERE is doing, there will be citizens still putting garbage on the streets... To facilitate traffic, we created special areas for loads and discharges of goods only, but there are people who park their cars in those areas for long periods of time and so we conclude that the success of the initiatives always depends on the citizens.

9. Q – **Some sort of re-education of the population is needed?**

A – Exactly. Nowadays almost everyone has a smartphone and we have facility to access various types of information instantly. It is good that citizens use all these tools to interact with the municipality. At the end of the day, the Smart Cities is everyone being connected, everyone knows what's happening in the city, in real time. For example, I see smart cities as cities that give their citizens examples of their status: "There's too much traffic here," or "There's plenty of parking here" and we have an open network, with the initiative wi-fi Braga, where everyone has free access to the network. Too bad it only exists in the downtown area...

10. Q – **...Is there any prospect of extending the coverage of the network?**

A – It's not a priority. There's free wi-fi in the downtown area and also in the municipal companies.

11. Q – **That's all. Anything else you want to add?"**

A – I forgot to mention that it makes sense to control the noise levels, especially in the downtown area where there are several bars and terraces, because we receive complaints every week. It would be interest to know, for example, at X date the Y

bar exceeded the allowed noise for Z hours. If this information existed we could notify the owner and take the legal actions. Complementing this, we could reward those bars that fulfilled the rules for an entire year. Those bars could be rewarded with the exemption of the payment of their terrace. This is another example that strengthens the importance of having a central that aggregates all the data and allows access to the history of the information.

3.6 INTERVIEW SUMMARY

This interview served to understand the vision of a local government, in the Smart City scope, and some conclusions can be taken and compared with the citizens priorities and also with the good practices delineated in the standards.

The Advisor to the City Councillor, João Luís Barros, defends that a Smart City should be essentially for citizens and the city of Braga is starting to take the first steps into a Smart City. One of the developed projects was the *Braga Resolve* initiative [40], that consisted in the creation of an web application where citizens can report city's flaws. Figure 19 shows the Interventions Map of the website's application, where the occurrences that are now being treated and those that have already been completed, can be seen, while Figure 20 shows an example of a complaint, in this case holes in the sidewalk. This project allowed to remove bureaucracy from the complaints, to turn the citizen into a fiscal agents and to show the citizens which processes the council is dealing with.

Also from this interview, it was possible to conclude that the Smart Mobility Area (see Figure 2) represents the main Smart City priority to the council. Programs that include smart crosswalks, smart traffic lights and the improvement of conditions given to pedestrians and cyclists are being equated. There's also interest in implementing initiatives in the Smart Environmental Area (see Figure 2). Increasing the city's green areas, improving the lighting system to LED and also placing displays under the traffic light that show information about city's air quality status, temperature and humidity are some of the initiatives being considered.

In his opinion, João Luís Barros defends that a data centre and a control room that aggregates, manages and allows real-time monitoring of all the information generated from the Smart City initiatives and projects would help the city's leadership in the resolution of problems in real time. Control the access to city's key places and also correct traffic lights malfunctions are some of the problems, that could be solved in a minutes if such data control room was implemented. Even so, this is not a priority for the city council.

In the areas of the public transportation and garbage collection some sustainable initiatives are being implemented. Some bus stops have small displays that inform citizens of the expected arrival time of a bus. Also, the company responsible for collecting urban waste is

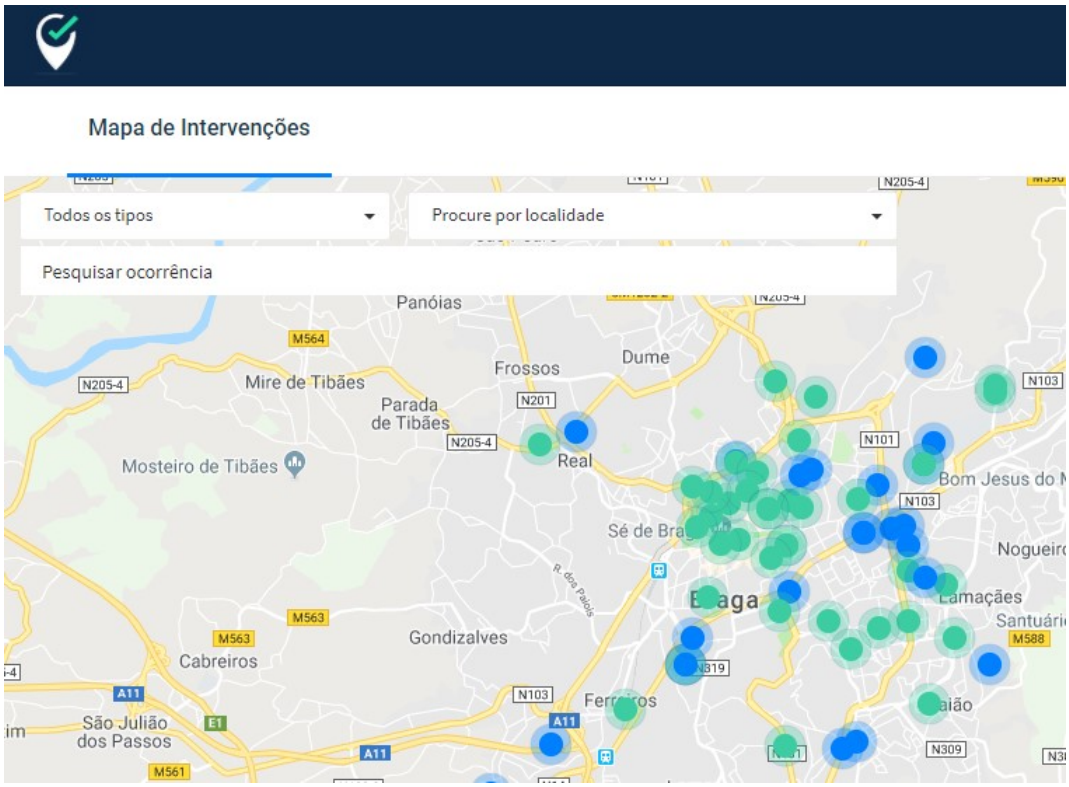

Figure 19: View from the Intervention Map of *Braga Resolve* website

implementing a new system of containers with the objective of ending the garbage on the streets where it can be accessed by animals and exposed to wind or rain (Figure 21).

Lastly, it can be concluded that a Smart City point system that rewards citizens that undertake sustainable activities might be implemented in a different way. João Luís suggested a system that could reward not only citizens but also small city businesses: local bars could be rewarded if there was no noise coming from their areas after hours of mandatory silence. This system would require the not only the measurement of the noise levels but also all the services required to store, access and process all the collected data, enhancing the idea of implementing a Smart City data centre.

Figure 20: Example of a complaint in the *Braga Resolve* website

Figure 21: Example of a new garbage container being dumped

4

SMART CITY GUIDELINE

This chapter is presentes the *Smart City Guideline (SCG)*, which is the main focus of this work, as well as the respective tips for proper use.

4.1 SMART CITY GUIDELINE

The main objective of this dissertation was the creation of a SCG that combines the good practices, imposed by the standards in force, and also the input and priorities of local citizens and governments. Since all the Smart City definitions studied include the use of technology, the SCG is based on the assumption that the ICTs will be used for the implementation of sustainable initiatives. The SCG can be used by governments, organizations or individual activities and can be applied to any city, regardless size and population number. Also, the citizen's group represents not only the city's inhabitants but also tourists and those who move to the city to work on a daily basis.

The proposed SCG is composed by 7 stages. Each stage has a set of topics, suggestions or examples that should be taken into consideration when implementing Smart City initiatives. The SCG is presented in Figure 22. It's important to note that the order of the guideline should be followed as presented, so stage 2 should only be implemented after stage 1 is complemented and so on.

4.2 STAGE 1: IDENTIFICATION OF THE PROBLEM

The first stage of the guideline is the identification or recognition of the problem and the consequent integration in the respective Smart City Area (see Figure 2) where the initiative can be included. The identification of the key stakeholders is also crucial for the success of the program. Implementing this Stage should require an in-depth knowledge about the city's infrastructures and limitations.

Also, it's crucial to identify if the initiative found requires a public share of real time information. If it does, citizens opinions and preferences should be taken into consideration

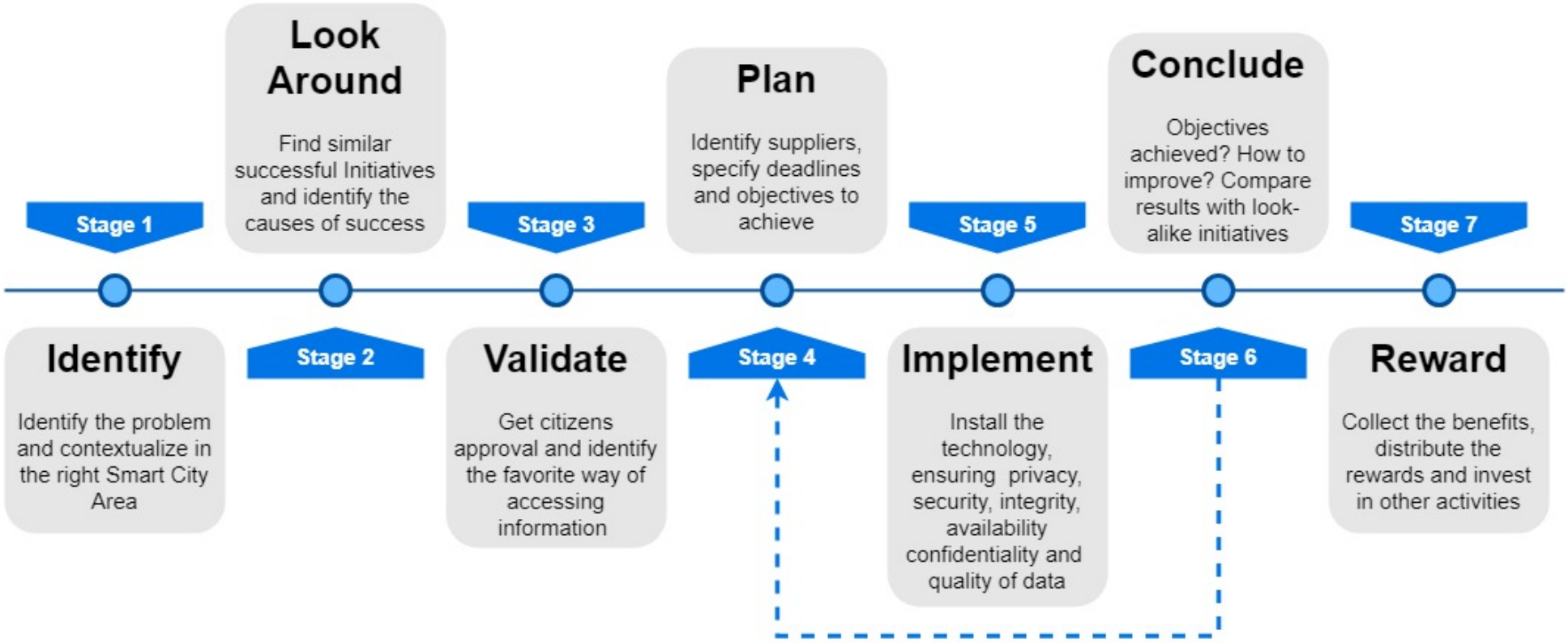

Figure 22: The Smart City Guideline (SCG)

since the citizen stakeholder group might be the one identifying the problem. So Smart City initiatives can be separated in two types:

> Type 1: Initiatives where the information gathered, from the collected data, needs to be shared, available in real time and open to use by everybody. These initiatives should require the citizens inputs and suggestions since they represent the end-user; and
>
> Type 2: Initiatives where only the implementation, technology used and the final results should be shared. These initiatives might not use the citizens inputs.

One example of an initiative where the data does not need to be permanently shared, but the implemented technology and the achieved results were made public, is a project developed by the government of Barcelona, where technology was used to save money and optimize infrastructures [31]:

> *"In Barcelona, the local government used the latest technologies and introduced Smart City initiatives, saving £37 million from smart lighting, £58 million from smart water measures, and increasing cash flow from parking by £50 million."*

In contrast, projects like smart parking or smart traffic initiatives, need a permanent information exchange with users. In these situations, when funds are limited, citizen's input might be crucial for the decision makers to help deciding which initiative should be considered first.

4.3 Stage 2: Find Similar Successful Initiatives and Founds

Every city is different and will face a great number of urbanization challenges. Even so, similar initiatives can be implemented, with success, in different cities. The second of the SCG consists in looking for other similar initiatives that were implemented with success. In this Stage, organizations should identify:

- Cities where a similar Smart City program was successfully implemented;
- Identify the major obstacles and handicaps that were overtaken;
- Which and how technology was used; and
- The best way to adapt the successful initiative to their city.

It's important to understand that a copy of the project might result in a failure, since defining Smart City goals and objectives begins with a deep understanding of citizens and local business needs, but also the community's unique attributes: its demographics,

infrastructures, traditions and resources. So cities should adapt other initiatives instead of copying them in full. As an suggestion, the Smart City standardization might be an excellent source of successful activities, since many case studies are presented in these documents. Examples of cities include Barcelona, Hamburg, Bristol, Boston, Birmingham, Stockholm, London or Glasgow, being mentioned in PAS 181 and PAS 184.

Finally, it's understandable that local governments might not have the economic needs for the implementation of the desired program. To avoid situations where initiatives aren't implemented due to lack of funding, an extensive exploration of funding opportunities should be taken into consideration. This may require collaboration between governments, corporations and international organizations in the creation of partnerships that aim to find solutions while erasing the funding gap.

4.4 Stage 3: Project Validation

The third step of the SCG consists in getting the inputs of the local citizens, when needed, in order to determine if the problem previously identified represents a priority for this critical Smart City stakeholder group.

Surveys, such as presented in section 3, might help organizations defining which initiatives represent priorities and deciding which technology to use. Also, citizens and governments can work together to achieve objectives. Smart City projects that aim to use the citizen's personal smartphones or car's sensors, could be more accepted if the initiative represents a priority to the citizens group.

Still regarding the validation of the initiative, citizens should have opportunities to express their preferences in how they access the generated information. Smartphone applications, public digital displays and websites might be needed to guarantee an easy access to the final heaps of information.

Lastly, the political commitment must be ensured, with clear leadership and with a community base, underwriting the need of permanent talks between the responsible teams and the end users (citizens). So, also in this stage and if needed, governments should create responsible teams to oversee and drive the program. Leaders should also take into account the need of respecting national and international policies, ensuring that every initiative follows the adopted standards activities, since they provide a common background and a similar terminology that all different stakeholders should use.

4.5 Stage 4: Strategy and Teams Definition

The fourth Stage of the SCG represents all the Strategic considerations needed to guarantee that the initiative has the desired success.

Engagement with all stakeholders is a critical point for Smart City programs [41]. After a study about the main citizens motivations and finding similar activities, governments should identify and engage with critical partners. These might include many groups or companies, such as small communities representatives, that express the direct needs of small citizens minorities, technology suppliers, that offer the best guarantees in terms of technological devices either in price and installation, but also developing teams, responsible for the creation of all the applications and services needed to guarantee the safe and easy access to critical information. Partnerships created should result in groups or teams where a clear division of roles is stipulated and formal responsibilities are assigned with direct input from citizens representatives. These teams should be responsible for overseeing the development and implementation of the program, ensuring that everything is implemented according to the plan previously stipulated.

The technology selection phase is very important, as technology should be chosen with proper cyber security controls and protections in mind. If organizations only consider the desired functionality, it could open city infrastructure up to possible cyber attacks [42][43], where critical and personal information could be used without the consent of the user.

Governments should take into consideration that a Smart City starts with having a realistic plan [44], so it's crucial to have a solid and realistic plan for the city's transformation. To achieve this, milestones, objectives and deadlines should be established when planning the Smart City program. This will also allow governments to have a clearer visions and terms of comparison: after the project is concluded, a comparison can be made with the objectives and milestones previously outlined.

4.5.1 *The Importance of Smart Data: Edge Approach*

Smart cities demand smart data [44]. By itself, technology and data don't make a city smarter, so data needs to be worked on and transformed into information and then can be used to make citizen's lives better.

This means that all collected data, from sensors deployed in a city, need to be gathered, labelled, related, stored and used not only to give real time information about the city's status but also to predict actions. Such acts reinforce the idea that a data centre might be a crucial step in implementing Smart City initiatives and must be considered. The data centre is the centralised storage space for all the data collected from the multiple sensors in the network. It provides real time data for effective operations and hosts applications that support the operation of video management or traffic and crowd control. The design of the data centre depends on the kind of applications that are run in the Smart City [43].

With this in mind, LabSecureIoT developed a server capable of aggregating and managing the data generated in an IoT environment. The server's architecture is based on the

concept of "Edge Computing", where intermediate machines, or "Edges", are strategically placed at the edge of the network, between the devices and the cloud [45][46]. This happens because it's assumed that the cloud cannot handle all the connections and information pre-processing, in an IoT environment. These machines have the responsibility to transform the low-level information, generated from devices, into high-level information but also to wipe out irrelevant data while storing critical heaps of information to allow the creation of predictive models.

The high-level structure of the "Edge" can be seen in Figure 23, where Smart City devices send permanent data to "Edge" servers. This data is categorized, processed and correlated, generating high-level information that is sent to the cloud and can be used by the applications of end-users (like smartphone applications or live digital displays presenting real time information).

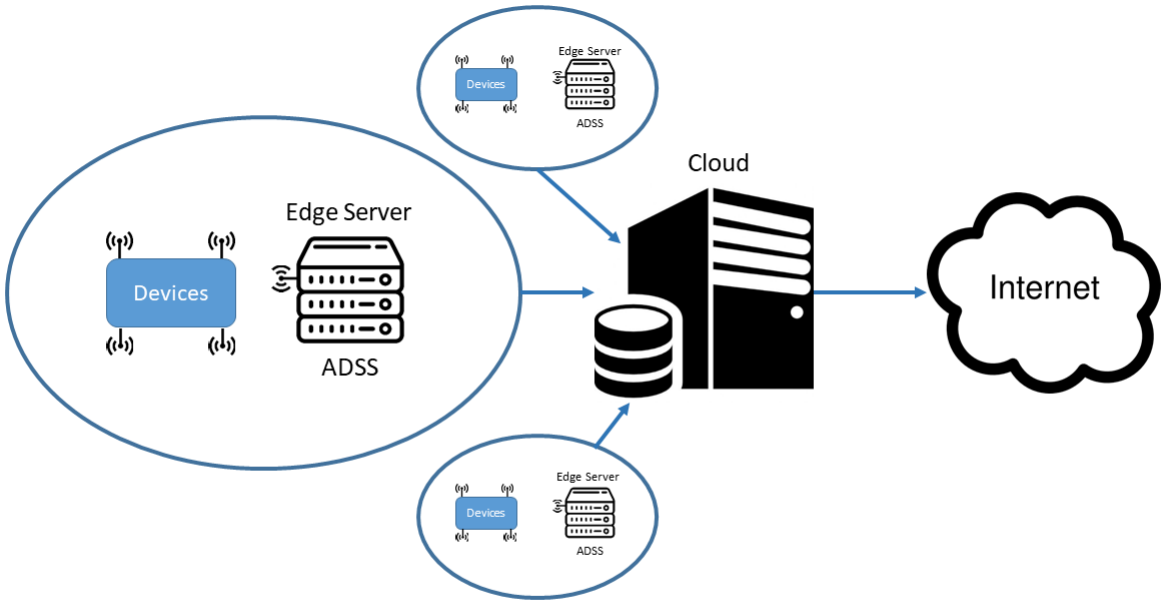

Figure 23: High-level presentation of the "Edge" server

One "Edge" might not be able to cover the entire city area. So many "Edges" can be placed in one city and the result information can be correlated between them.

4.6 Stage 5: Implementation

With a good strategy in place and a responsible team defined, it's possible to start the implementation and realisation of the plan. Technology acquired from the partners previously chosen can now be installed and data can be collected.

While each city corner is a possible place for a device insertion, it is necessary to ensure the safety and anonymity of citizens when their data or images are collected. Related to the captured data from the installed sensors, responsible teams and developers should guarantee that the following aspects are ensured:

- Privacy: *freedom from intrusion into the private life or affairs of an individual when that intrusion results from undue or illegal gathering and use of data about that individual* [17];
- Confidentiality: *property that information is not made available or disclosed to unauthorized individuals, entities or processes* [17];
- Integrity: *information is not altered in any way, deliberately or accidentally* [17]; and
- Availability: *process of ensuring that data is available to end users and applications, when and where they need it* [47].

It is also important to guarantee that technology is combined with the right use of data, leading to the conclusion that smart cities might need to implement a command centre, that provides an infrastructure that assess the integrated information provided by the data centre such as live video for incident response. With alert systems and teams of supervisors, the command centre allows quicker analysis of data for better and faster decision making. When an alert is issued, responsible teams can act quicky reaching the critical spot in a faster way.

Beijing (China) is an example of a city that integrated many command centres in the implementation of Smart City activities [48]:

> Beijing implemented a urban and interurban traffic control system. The information about traffic signals, monitoring system for expressway , CCTV around the streets, traffic flow detection services, weather prediction and detection and guidance systems, were integrated in 10 command centres.

In the case of Beijing, with a population of 21.7million [49], one command centre might not be enough to monitor all the city area, leading to the conclusion that, like the data centre, the design of the command centre depends on the kind of applications that are run in the Smart City.

4.7 STAGE 6: CONCLUSIONS

Once implemented, the project's appropriate conclusions can be withdrawn. By implementing checklists, such as presented in the Annex B of the standard PAS 181 and all across the standard PAS 184, critical comparisons can be drawn. An evaluation of the program's results should then be carried out.

First, it is crucial to conclude if the objectives previously defined were achieved and the deadlines respected. If not, it is important to understand why. Secondly, it is crucial to guarantee if it is necessary to change stakeholders and partners, so an adaptation and fine-tuning of specific operations can be performed. This might include a step back to the SCG Stage 4. Finally, it is important to ensure that the initiative is sustainable in the future, so maintenance and adjustment of the plan to new urban conditions is crucial and should be taken into consideration.

4.8 STAGE 7: REWARD

The last Stage of the SCG consists in collecting and distributing the rewards resulted from the Smart City initiative.

If large savings were achieved in monetary terms, some of the saved money should be used to guarantee the innovation of the program, like upgrading infrastructures or devices, while the other part of the savings should be used to implement other Smart City initiatives.

In cases where citizens and governments worked together, citizens that undertook smart and sustainable activities during the Smart City program should be rewarded for their contribution. Rewards might include discounts in the daily life of citizens like price reduction in public transportation passes or free entrances in local museums and concerts.

4.9 EXAMPLE OF APPLICATION: SMART PARKING

In this subsection a basic example of usage of the SCG is presented.

As previously stated, the traffic congestion is one of today's biggest problems for cities and a significant portion of traffic in urban areas is generated by drivers searching for an available parking space. This problem represents not only a waste of fuel and time for the drivers stuck in traffic but it also increases air and noise pollution [50][51][52]. With this in mind, the example given next tries to simulate the usage of the SCG in a Smart City scenario where the local government tries to find a solution for the problem identified above.

Stage 1: Identification of the problem – The problem is identified: high volume of car traffic in the downtown area, due to lack of public parking spaces. With the main objective

of correcting this problem, the local government proposes a smart parking program that informs users of the public parking slots in real time, providing their status (free or occupied), location and the best route to get there. This initiative can be integrated in the Smart Mobility area (see Figure 2) and since the main objective is to give drivers, the main stakeholder, a real time map of the city's free parking slots, the initiative should have the citizens input about its importance and how would they prefer to access the final information.

Stage 2: Similar initiatives – An example of a similar initiative includes the city of Westminster (United Kingdom), where the IoT was used to provide real time information about the city's parking slots [53]. In a mobile application, drivers can see all the city's parking spaces and if they are occupied or not. This initiative helped lower the car congestion and CO2 emissions, by reducing time spent finding parking spaces.

Stage 3: Project validation – Since citizens represent the main stakeholder in this initiative, a survey should be conducted to identify if the program represents a priority for local drivers and how they prefer to access the final information. As an example, the fourth question asked in the presented survey (Chapter 3) shows that citizens would use an mobile application capable of displaying these types of information Figure 13.

From the main standards, ISO 37120 identifies that the number of personal automobiles per capita represents a core indicator in the transportation section. The measurement of this indicator can shed light on travelling behaviours and can also inform the need for further transport facilities or the increment of public parking spaces. Also, the smart parking program matches the recommendations given by PAS 181 and PAS 184: the vision is focused around a citizen need and it aims to improve the way that city's function, while reducing pollution, in a sustainable way.

Stage 4: Strategy definition – This initiative would consist in the installation of small sensors in all parking spaces that identify if the spot is free or occupied, in real time. The sensor sends the data, via wifi, to an "Edge" server that aggregates and manages all the information. Finally, the server sends the result information to an online application that informs the drivers where is the closest free parking slot. Responsible teams should define milestones and deadlines while engaging with the various stakeholder groups: technologies providers, mobile developers and the entity responsible for the management of the public roads, where the sensors will be installed. To evaluate if the plan is understandable by every party involved, checklists proposed by the standard PAS 184 can be used. Some of the topics of these checklists include questions that the project's leaders should ask themselves such as:

- *"Can we describe how life in the city will look and feel different as a result of our project?"*
- *"Do we know how to measure progress towards our vision?"* and

- *"What new sorts of value-added services could we provide to our customers digitally?"*

Stage 5: Implementation – Technology, acquired from the providers, should be installed and information sent to the mobile application. Since the application is used by drivers, private and critical data must be secured, like citizen's identifications or car registration characters. Final information should follow the recommendations of PAS 182: data should be described, catalogued and related in a way that it makes easy to use and allows interoperability between other sectors.

Stage 6: Conclusions – Objectives and milestones, previously stipulated in the fourth stage, can be evaluate. Since the project relies on a concrete and measurable indicator, the average time that drivers lose by searching for a public parking spot, comparisons can be made between the time spent before and after the program was implemented but also with other cities that adopted similar initiatives. Lastly, improvements to the program can be proposed and, if needed, a new plan should be drawn.

Stage 7: Rewards – Drivers who have installed and used the application have proven that the average time to find a parking space has been reduced, resulting in less fuel consumption and an improved city's overall air quality. These drivers can be rewarded with access to special parking spots for some periods of time or reduced costs in car maintenance companies (partners of local council).

5

CONCLUSIONS

In this chapter are presented the main conclusions on the present work. Furthermore, this chapter also contains suggestions to improve and expand upon the work done in this dissertation.

5.1 CONCLUSIONS

Cities are growing at an unprecedented rate, causing a new wave of problems that are becoming obstacles to local and national governments and urban planners. In order to solve these problems, cities need a more intelligent and sustainable planning, based on technology. This will create a more thoughtful urbanism for citizens, while increasing a new set of opportunities for businesses, to the public and private community.

The main objective of this work was to propose a Smart City Guideline that aggregates the good practices suggested by the main standards in force, in the Smart City context. Standards are crucial for the success of Smart City programs, since they provide tools to achieve interoperability, a common language to different stakeholders and enable scalability. Furthermore, a study about the impact of the identified good practices on society was also carried out: a survey to the urban population, that aimed to understand the main priorities of these critical stakeholder group, and a interview with João Luís Barros, Advisor to the city Councillor, in the city of Braga, with the main objective of understanding the main priorities but also the obstacles and difficulties of implementing Smart City projects by a local government.

Some of the standards studied include the ISO 37101 – Management system for sustainable development, ISO 37120 – Indicators for city services and quality of life, PAS 181 – Guide to establishing strategies for smart cities and communities, PAS 182 – Guide to establishing a model for data interoperability and PAS 184 – Developing project proposals for delivering smart city solutions. Some cities, that implemented Smart City programs and are referred in these standards include Barcelona, Hamburg, Bristol, Boston, London or Glasgow. From the in-depth study of the standards, a list of good practices could be drawn, including suggestions like the need to set a strong and inclusive strategic approach, the

need to share and open data to everyone and also the need to create conditions for citizens and governments to work together with the objectives of reducing costs and promoting behavioural changes.

The evaluation of standard's effects on society has led to the conclusion that the priorities of both citizens and local governments are in line with the Smart City Areas presented and good practices suggested by the standards. Both groups defend that the Smart City initiatives should concentrate efforts in the areas of the Smart Mobility and Smart Environment, while citizens and local businesses should be rewarded for implementing sustainable activities.

The proposed Smart City Guideline can be used by governments or individual activities and is based on the assumption that the ICT will be used to implement inclusive and sustainable initiatives. To facilitate its use, a simple scenario is given as example: the implementation of a Smart Parking program.

5.2 PROSPECT FOR FUTURE WORK

The permanent identification and study of the main standard activities is crucial for the right implementation of Smart City programs. Since the standardization is in constant development, it's important to keep track of the new published standards. PAS 181 has been recently published as international standard, ISO 37106, and a study of this document should be performed in the near future.

Also, initiatives that take into consideration the proposed Guideline, should give constructive inputs in how to improve the proposed document, based on experience with exemplification, identification of limitations but also difficulties found when implementing all the necessary security needs.

Finally, an identification of concrete metrics or key performance indicators, allowing measurable comparisons between different cities, should be considered in a future work. Metrics can help measure the performance of many initiatives and may indicate the "smartness" level of a city, while monitoring the city's progress into a Smart City.

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A

ANNEX A - COMPLETE SURVEY QUESTIONS AND ANSWERS

The survey, presented in section 3, had in total 210 questionnaires were answered, till 4th of September 2018.

A.1 QUESTION 1

Gender:

- *Male*
- *Female*

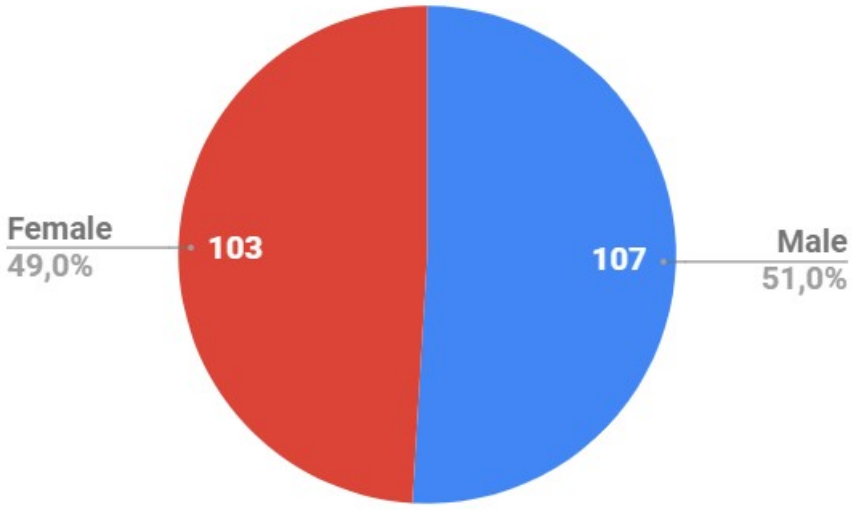

Figure 24: Answers to the seven questions about the Gender

A.2 QUESTION 2

Age:

- *17 or less*
- *18 to 30*
- *31 to 45*
- *46 to 60*
- *61 or more*

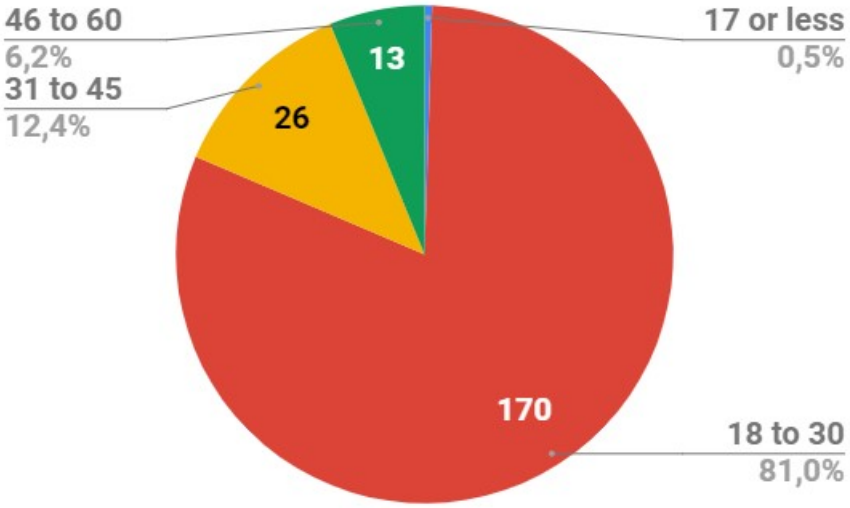

Figure 25: Answers to the seven questions about the Age

A.3 GROUP OF QUESTIONS 3

"Would you use a service or application capable of presenting real time information about:

1. *The air quality status in various parts of the city?*
2. *The temperature and humidity of the air in several points of the city?*
3. *The traffic status in the city?*
4. *The status of parking slots (free or busy) of public parking, in strategic points of the city?*
5. *The average noise level in various parts of the city?*
6. *The location of public transports and the estimated time of arrival at a certain location?*
7. *The location of garbage collection vehicles and the estimated time of arrival at a particular location?"*

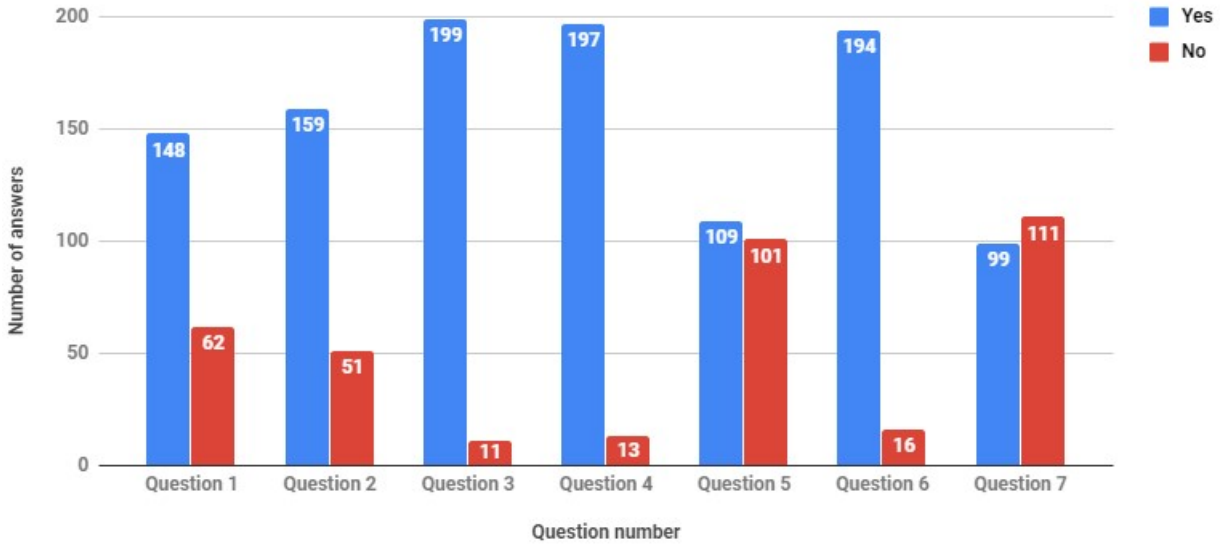

Figure 26: Answers to the seven questions about the Smart City status and variables

A.4 Group of Questions 4

"Considering the cases previously presented, how would it be more interesting to observe these types of information? (Multiple answers can be selected)"

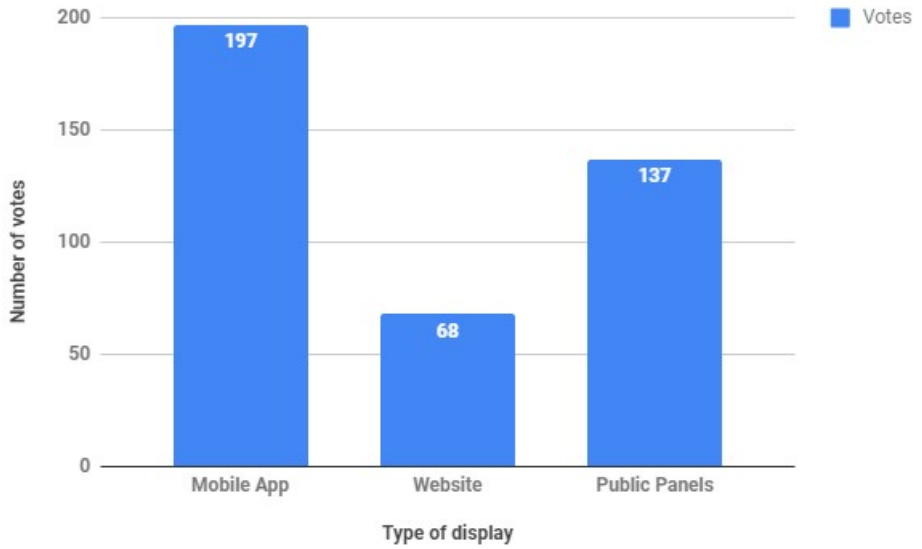

Figure 27: Answers to the question about display of the information

A.5 Question 5

"Do you consider monitoring of air quality in a city important?"

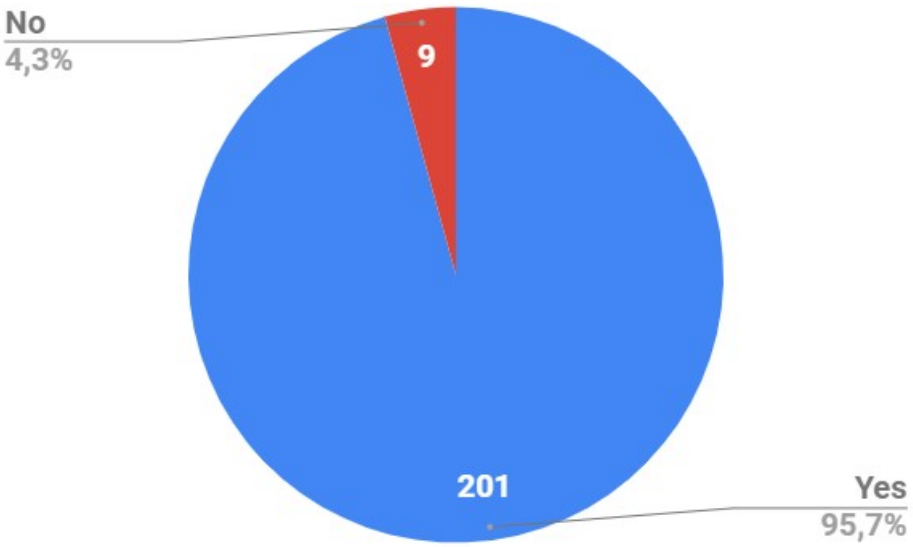

Figure 28: Answers to the question about the importance of monitoring the city's air quality

A.6 QUESTION 6

"Like the audiovisual services, would you be willing to pay a symbolic monthly fee so that this type of information is publicly available?"

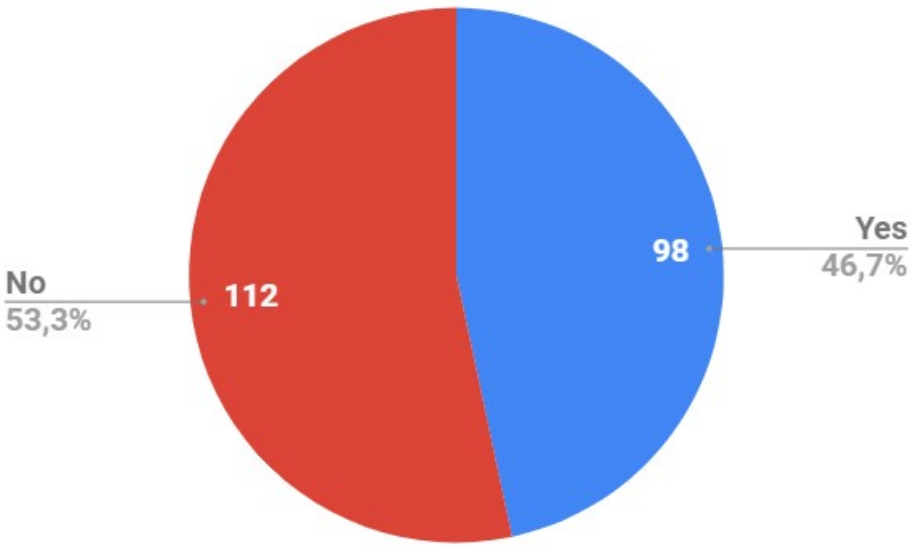

Figure 29: Answers to the first question about the business model

A.7 Question 7

"If you answered "no" to the previous question, would you be willing to buy a mobile application that would provide this type of information?"

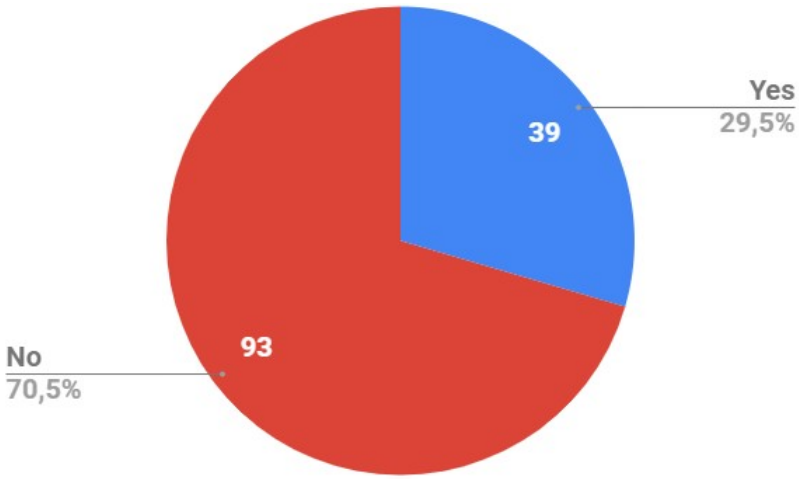

Figure 30: Answers to the second question about the business model

A.8 Question 8

If a Smart City point system is implemented, where citizens are rewarded for doing urban sustainability activities (recycling, using public transport, etc.), would you feel more attracted to these types of services? (The points could represent discounts in the daily life of citizens)

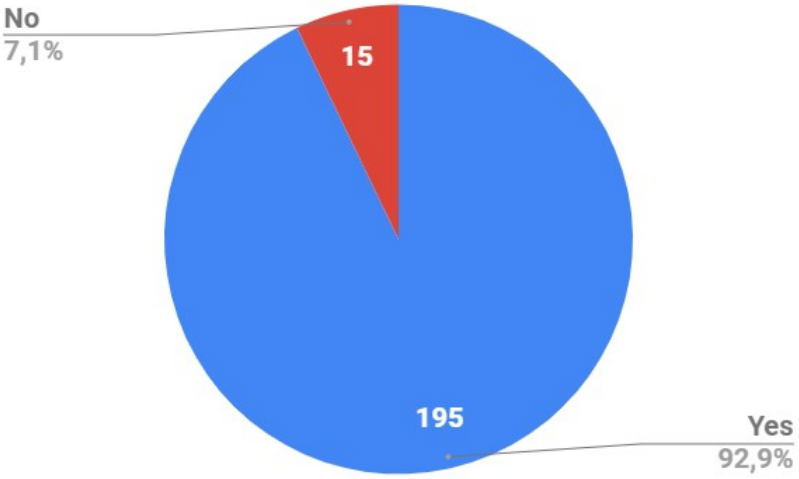

Figure 31: Answers to the question about the reward system

NB: place here information about funding, FCT project, etc in which the work is framed. Leave empty otherwise.